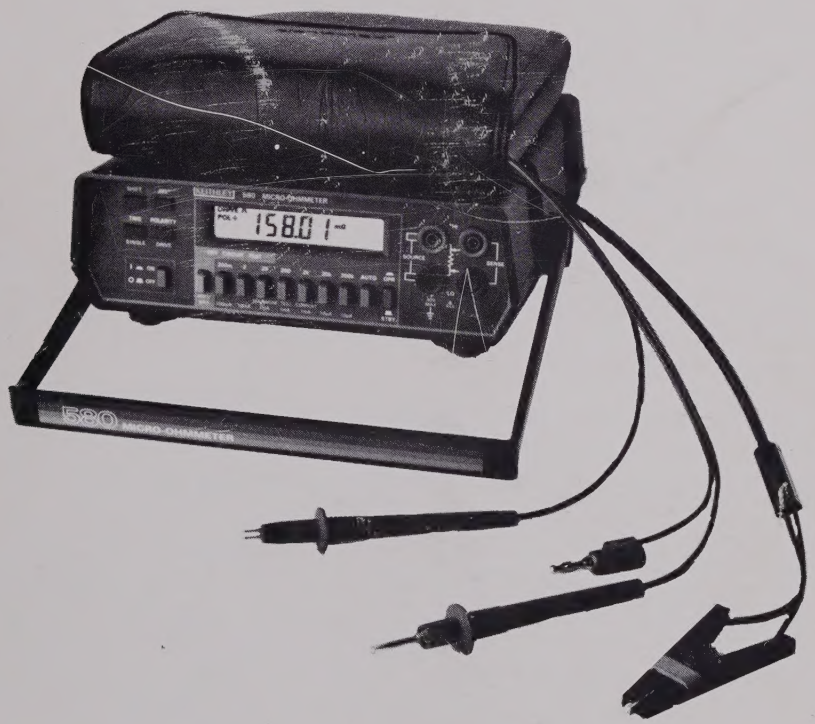
KEITHLEY INSTRUMENTS

Model 580 Micro-ohmmeter Service Manual



Contains Servicing Information for the Models 580 and 1978 Battery Pack

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Model 580
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SPECIFICATIONS/580

Range	Resolution	Maximum Test Current	Non Dry Circuit Test Accuracy 1 Year, 18°-28°C ± (%Rdg + Counts) Pulsed	Non Dry Circuit Test Accuracy 1 Year, 18°-28°C ± (%Rdg + Counts) DC	Dry Circuit Test Maximum Power Dissipation in Sample	Dry Circuit Test Accuracy 1 Year, 18°-28°C ± (%Rdg + Counts) Pulsed
200mΩ	10 μΩ	100mA	0.04 + 2	0.04 + 3	500μW	0.05 + 2
2 Ω	100 μΩ	10mA	0.04 + 2	0.04 + 3	50μW	0.05 + 2
20 Ω	1mΩ	1mA	0.04 + 2	0.04 + 3	5μW	0.05 + 2
200 Ω	10mΩ	1mA	0.04 + 2	0.04 + 2		
2 kΩ	100mΩ	1mA	0.04 + 2	0.04 + 2		
20 kΩ	1 Ω	10 μA	0.05 + 2	0.05 + 2		
200 kΩ	10 Ω	10 μA	0.075 + 2	0.075 + 2		

CONFIGURATION: 4-wire (two sense, two source).

MAXIMUM SOURCE VOLTAGE: 20mV in Dry Circuit Test, 1V otherwise.

MAXIMUM TEST LEAD RESISTANCE

200mΩ and 2Ω Ranges: Up to 5Ω in each SOURCE lead and 10Ω in each SENSE lead with Non Dry Circuit Test; up to the selected full range resistance in each SOURCE lead and 10Ω in each SENSE lead with Dry Circuit Test.

20Ω through 200kΩ Ranges: Up to half of the selected range in each test lead.

CONVERSION RATE: 3 readings/second typical.

RANGING: Auto or manual.

AUTORANGING TIME: 200ms per range change, average.

SETTLING TIME: Less than 1 second to within 10 counts on range.

MAXIMUM INPUT OVERLOAD: 10V limited to 10A.

MAXIMUM COMMON MODE VOLTAGE: 30V rms at dc, 50 or 60Hz.

TEMPERATURE COEFFICIENT (0°-18°C and 28°-50°C): ±(0.1 × applicable accuracy specification)/°C.

GENERAL

DISPLAY: ±20,000 count LCD, range and status information displayed.

OVERRANGE INDICATION: "OL" displayed.

CONNECTORS: Measurement and rear panel EXTERNAL TRIGGER inputs: Banana jacks.

RELative: Allows zeroing of on-range readings. Allows readings to be made with respect to baseline value. Display annunciator indicates REL.

DRIVE: Selects either pulsed or dc SOURCE current. Pulsed drive provides automatic cancellation of thermal offsets, using 50% duty cycle pulse. Display annunciator indicates drive selected.

POLARITY: Selects either positive or negative SOURCE current in either drive. Display annunciator indicates polarity selected.

TRIGger: Allows single pulsed measurements.

OPERATING ENVIRONMENT: 0°-50°C, less than 80% R.H. up to 35°C; linearly derate 3% R.H./°C from 35° to 50°C.

STORAGE ENVIRONMENT: -25° to +60°C.

POWER: 105-125V or 210-250V (switch selected), 90-110V available. 50-60Hz, 12VA. Optional 6 hour battery pack, Model 1978.

DIMENSIONS, WEIGHT: 89mm high × 241mm wide × 300mm deep (3½in. × 9½in. × 11¾in.). Net weight 3.2kg (7 lbs.). Test lead pouch adds 76mm (3in.) in height.

ACCESSORIES AVAILABLE:

Model 1010: Single Rack Mounting Kit.
Model 1017: Dual Rack Mounting Kit.
Model 1755: Calibration Interface.
Model 1978: Rechargeable Battery Pack.
Model 5801: Test Lead Pouch.
Model 5802: Isolated Analog Output/IEEE-488 Interface.
Model 5804: Test Lead Set.
Model 5805: Kelvin Probes.
Model 5806: Kelvin Clip Leads.
Model 7007-1: Shielded IEEE-488 Digital Cable (1m).
Model 7007-2: Shielded IEEE-488 Digital Cable (2m).
Model 7008-3: IEEE-488 Digital Cable (3ft.).
Model 7008-6: IEEE-488 Digital Cable (6ft.).
Model 8003: Low Resistance Test Fixture.

ACCESSORIES SUPPLIED: Models 5801, 5804, 5805, 5806, Operator's and Service Manuals.

Safety Precautions

The following safety precautions should be observed before operating the Model 580.

This instrument is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read over the manual carefully before operating this instrument.

Exercise extreme caution when a shock hazard is present at the instrument's input. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V rms or 42.4V peak are present. **A good safety practice is to expect that a hazardous voltage is present in any unknown circuit before measuring.**

Inspect the test leads for possible wear, cracks or breaks before each use. If any defects are found, replace with test leads that have the same measure of safety as those supplied with the instrument.

For optimum safety, turn the power off and discharge all capacitors before connecting the instrument. Always disconnect all unused test leads from the instrument.

Do not touch any object which could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface, capable of withstanding the voltage being measured.

Exercise extreme safety when testing high energy circuits (AC line or mains, etc.). Always disconnect power before performing measurements.

Do not exceed the instrument's maximum allowable input as defined in the specifications.

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Preface

This manual contains information regarding installation, service and calibration of the Model 580 Micro-ohmmeter and optional Model 1978 Battery Pack. Fuse replacement, line voltage selection, troubleshooting and parts replacement are also covered in this book.

SECTION 1 presents general installation information.

SECTION 2 describes performance verification methods.

SECTION 3 describes front panel and IEEE-488 calibration of the Model 580.

SECTION 4 explains principles of operation.

SECTION 5 lists troubleshooting tips.

SECTION 6 contains replacement parts ordering information, component location drawings and schematic diagrams.

SECTION 1
General Information

1.1 INTRODUCTION

This section contains general installation and service information for the Model 580 Micro-ohmmeter and optional Model 1978 Battery Pack.

WARNING

The procedures described in this section are intended for use by qualified service personnel only. Do not perform these procedures unless qualified to do so. Many of the steps covered in this section expose the individual to potentially lethal voltages that could result in personal injury or death if normal safety precautions are not observed.

1.2 TOP COVER REMOVAL/INSTALLATION

The top cover of the Model 580 must be removed in order to service the unit or install the Model 1978 Battery Pack and/or the Model 5802 IEEE-488 Interface. Proceed as follows:

WARNING

Disconnect the line cord and all other equipment from the Model 580 before removing the top cover.

1. Turn off power, disconnect the line cord and remove all test leads from the terminals of the Model 580. Remove test lead pouch.
2. Turn the unit over and remove the four screws from the bottom of the case.
3. Turn the unit over again and separate the top cover from the rest of the unit.
4. To reinstall the top cover, position the tilt bail properly into the bottom cover; replace top cover and screws. Be sure front panel is properly seated in groove.

1.3 BATTERY PACK (Model 1978) INSTALLATION

There are three parts to the Model 1978 Battery Pack: the battery assembly, a bracket, and a charging circuitry board.

Refer to Figure 1-1 and perform the following procedure to install the battery pack:

1. Unplug the line cord and remove all test leads from the Model 580 terminals.
2. Remove the top cover as explained in paragraph 1.2.
3. Remove the shield by removing the screw located at the rear of the shield. Then, carefully lift the shield out of the Model 580.
4. Position the charging circuitry board on the shield as illustrated in Figure 1-1 and secure it to the top of the shield using the two supplied screws. The screws are routed through the bottom of the shield and up into the board fasteners.
5. Place the battery pack in the mounting bracket and position on the shield as illustrated in Figure 1-1, making sure the red and black battery lead wires face the front of the instrument. Route the two screws through the bottom of the shield then into the bracket and tighten.

CAUTION

Do not allow the battery leads to short together. Damage to the batteries may result.

6. Carefully place the shield with the battery pack into the Model 580 so that it seats properly on the two plastic spacers.
7. Reinstall the screw located at the rear of the shield.

NOTE

This is an important step as the screw not only secures the shield, it also connects the shield to circuit common.

8. Connect the ribbon cable from the battery board to the male connector J1009 (marked BAT) on the mother board. Be sure correct orientation is observed (see Figure 1-1).
9. Connect the red battery lead to the +RED terminal pin (P1010) on the battery board.
10. Connect the black battery lead to the −BLK terminal (P1011) on the battery board.

CAUTION

Carefully inspect the battery board to ensure that J1009, P1009, P1010 and P1011 are properly connected. Faulty operation or damage to the instrument may result if connectors are not properly fastened.

11. Reinstall the top cover as explained in paragraph 1.2.

NOTE

The Model 5802 IEEE-488 Interface does not operate on battery power.

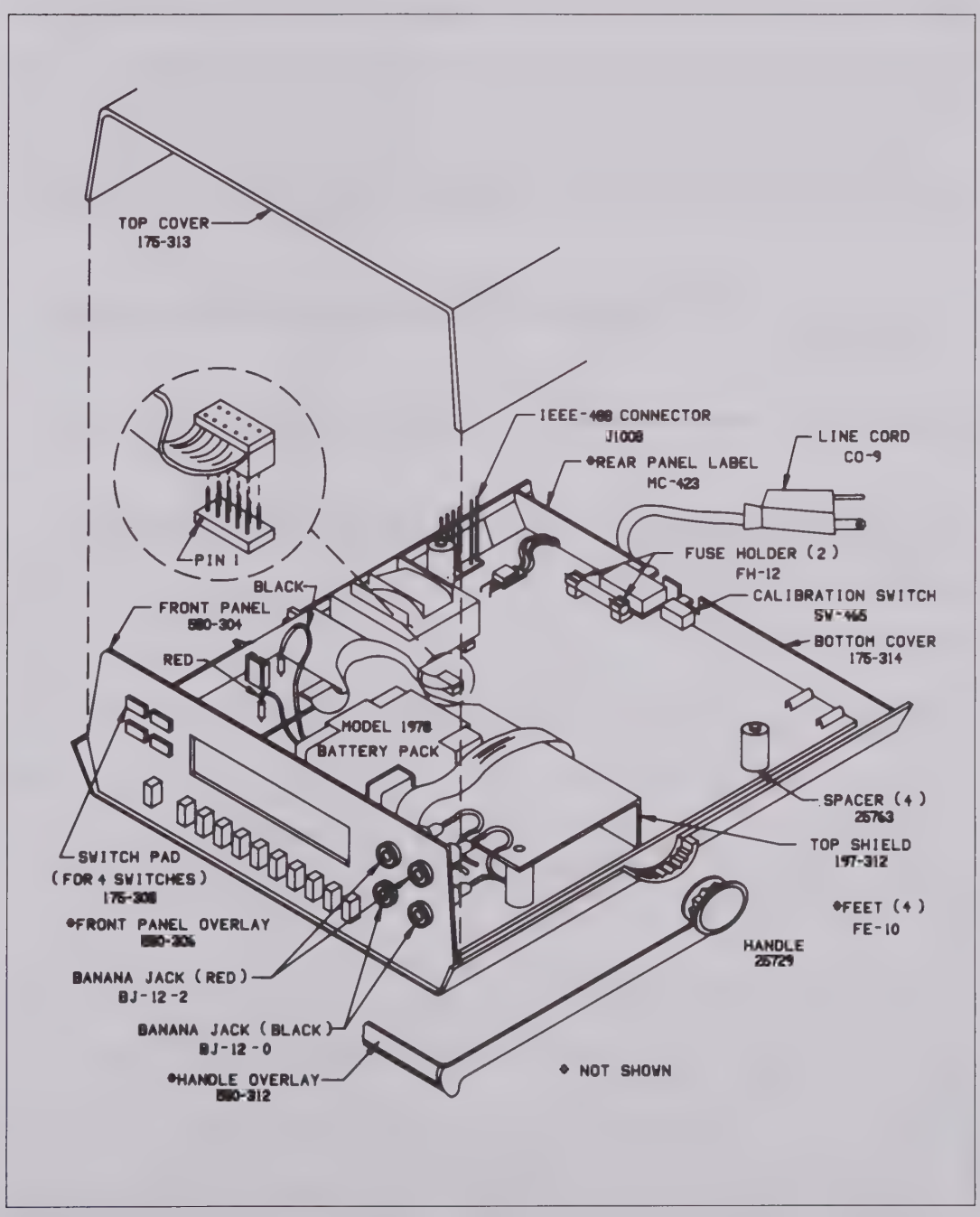


Figure 1-1. Model 580 Exploded View

1.4 LINE VOLTAGE SELECTION

The Model 580 may be operated from either 105V-125V or 210V-250V, 50-60Hz. A special transformer may be installed for 90-110V or 195-235V operation. The instrument was shipped from the factory set for an operating voltage marked on the rear panel. To change the line voltage, proceed as follows:

1. Turn off the Model 580 and disconnect it from line power.
2. Set the LINE VOLTAGE switch on the back of the instrument to correspond to line voltage available. Example: 110V AC is available, set the switch to 105V-125V.

CAUTION

Connect only to the line voltage selected. Application of incorrect voltage can damage the instrument.

3. Plug the power cord into a properly grounded outlet.

WARNING

Ground the instrument through a properly grounded receptacle before operation. Failure to ground the instrument can result in severe injury or death in the event of a short circuit or malfunction.

1.5 LINE FREQUENCY

The Model 580 may be operated at 50Hz or 60Hz line frequency. To check if the instrument is set to proper line frequency, perform the following:

1. Power up instrument. Frequency selection will immediately be displayed, F50 for 50Hz or F60 for 60Hz.
2. To change frequency setting, place CALIBRATION switch in ENABLED.
3. Turn off instrument, then power up again while pressing SHIFT to place the Model 580 in 60Hz, or power up while pressing the POLARITY button to place the Model 580 in 50Hz.
4. Place CALIBRATION switch in DISABLED.

1.6 LINE FUSE REPLACEMENT

The line fuse is located internally in the Model 580. For exact fuse location refer to Figure 1-1. To replace the fuse proceed as follows:

1. Unplug the line cord and remove all test leads from the Model 580 terminals.
2. Remove the top cover as explained in paragraph 1.2.
3. If the Model 5802 IEEE-488 Interface is installed, it must be removed to access the fuse. The IEEE-488 board is secured to the mother board by a support post at the rear and connector P1008. To remove, lift the board up until it disengages from the connector and support post.

4. Replace the blown fuse with the following type: $^1/_8$ A, 250V, 3AG, Slo-Blo (Keithley Part Number FU-20)

CAUTION

Do not use a fuse with a higher rating than specified or instrument damage may occur. If the instrument persistently blows the fuse, a problem may exist within the instrument. If so, the problem must be corrected before operation may continue.

5. If the IEEE-488 interface was installed, reinstall the interface as follows:
   A. Position the interface board above the three rear standoffs.

WARNING

Do not push down on J1008 (the white Molex connector). The male connector pins will pass through J1008 and may cause personal injury.

   B. Guide the terminals of P1008 and firmly push down on that end of the board to mate the connectors.
   C. Push down on the other side of the interface board until it snaps onto the rear-most standoff. Make sure the board is properly seated on the other two standoffs.
6. Reinstall the top cover as explained in paragraph 1.2.

SECTION 2
Performance Verification

2.1 INTRODUCTION

This section contains information necessary to verify that the Model 580's performance is within specified accuracy. Model 580 specifications may be found at the front of this manual. Ideally, performance verification should be performed when the instrument is first received to ensure that no damage or change in calibration has occurred during shipment. The verification procedure may also be performed whenever instrument accuracy is suspect, or following calibration. If performance on any of the ranges or functions is inconsistent with specifications, calibration should be performed as described in Section 3 of this manual.

NOTE

If the instrument does not meet specifications and is still under warranty (less than 12 months since date of shipment), contact your Keithley representative or the factory to determine any action to be taken.

2.2 ENVIRONMENTAL CONDITIONS

All measurements should be made at ambient temperature between 18°C and 28°C (65°F to 82°F) with a relative humidity of less than 80%.

2.3 RECOMMENDED TEST EQUIPMENT

The following equipment may be used to verify performance of the Model 580 (alternate equipment of equivalent accuracy may also be used):

2Ω-200kΩ Ranges—Fluke Model 5450A Resistance Calibrator.

200mΩ Range—0.19Ω 4-wire resistor, known to ±50ppm with ±20ppm/°C temperature coefficient.

In place of the Fluke 5450A, individual resistors that are 95% of the particular range to be calibrated and are known to ±50ppm (±20ppm/°C) may also be used. See Section 3.2 for sources of these resistors.

2.4 INITIAL CONDITIONS

Before performing these verification procedures, make sure the following conditions are met:

1. If the instrument has been subjected to temperatures below 18°C (65°F) or above 28°C (82°F), allow sufficient time for the instrument to reach temperatures within the range. Generally, it takes one hour to stabilize an instrument that is 10°C (18°F) outside of this range.
2. Turn on the Model 580 (allow it to warm up for one hour if the IEEE-488 interface is installed). The instrument may be operated from either line power or battery pack power, as long as the battery pack has been fully charged as described in paragraph 2.2.4 of the Operator's Manual.

2.5 VERIFICATION PROCEDURE

The following paragraphs give the basic resistance measurement verification procedure for the Model 580.

Resistance verification is performed by connecting known, precise resistance values (calibration resistors) to the SOURCE HI and SENSE HI terminals and the SOURCE LO and SENSE LO terminals and checking to see that the displayed reading is within the required limits. Compare displayed readings to Table 2-1 and see if they are within specified limits.

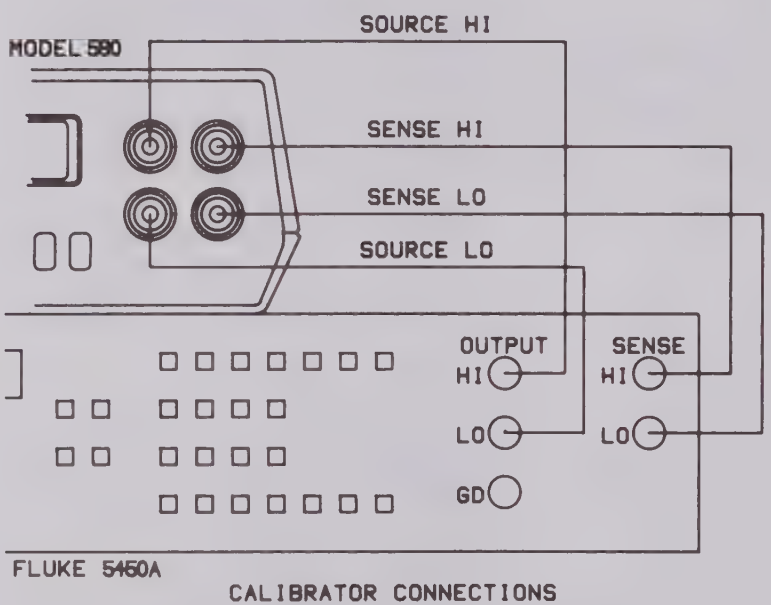
NOTE: Be sure to test both drives in both polarities when verifying the resistance values in Table 2-1. Also, verify that the proper annunciator is displayed (see paragraph 2.3.1 of the Operator's Manual).

1. Make sure the instrument is in STBY. (Always put instrument in STBY before taking readings in DRIVE ⎓ . See Operator's Manual for more information.)
2. Insert Keithley test leads (such as the Model 5804) into the SENSE HI and SOURCE HI, and SENSE LO and SOURCE LO terminals.
3. Connect a 190mΩ calibration resistor as shown in Figure 2-1. Note that this is a four terminal configuration. Be sure that the test clips are firmly clamped to the resistor to get an accurate measurement.
4. Put instrument in OPR.
5. Check to see that the displayed reading is within the limits specified in Table 2-1.
6. Repeat steps one through five, replacing the 190mΩ calibration resistor with other calibration resistors up through 190kΩ. Be sure to place the Model 580 on the correct range for each measurement.
7. Now, repeat steps one through five for the three Dry Circuit Test ranges.

Table 2-1. Limits For Resistance Verification

580 Range	Applied Resistance	Allowable Readings (18°C-28°C)			
		Non Dry Circuit Test		Dry Circuit Test	
		Pulsed	DC*	Pulsed	DC*
200mΩ	190.000mΩ	189.91 to 190.09mΩ	189.90 to 190.10mΩ*	189.89 to 190.11mΩ	189.81 190.19mΩ
2 Ω	1.90000 Ω	1.8991 to 1.9009Ω	1.8990 to 1.9010Ω*	1.8989 to 1.9011Ω	1.8981 1.9019Ω
20 Ω	19.0000 Ω	18.991 to 19.009Ω	18.990 to 19.010Ω*	18.989 to 19.011Ω	18.981 19.019
200 Ω	190.000 Ω	189.91 to 190.09Ω	189.91 to 190.09Ω		
2 kΩ	1.90000 kΩ	1.8991 to 1.9009kΩ	1.8991 to 1.9009kΩ		
20 kΩ	19.0000kΩ	18.989 to 19.011kΩ	18.989 to 19.011kΩ		
200 kΩ	190.000 kΩ	189.84 to 190.16kΩ	189.84 to 190.16kΩ		

*Set up measurements with instrument in STBY. See text.



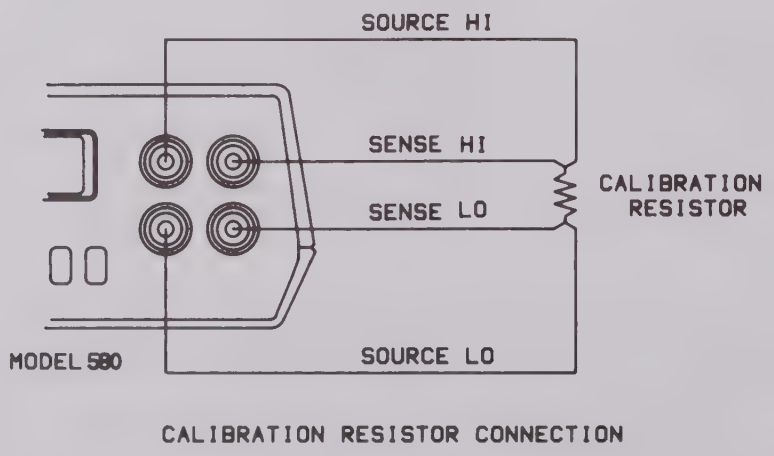


Figure 2-1. Connections for Four Terminal Resistance Verification

SECTION 3
Calibration

3.1 INTRODUCTION

Digital calibration eliminates calibration potentiometers. All calibration factors for each range are stored in non-volatile RAM (NVRAM).

The instrument can be calibrated from the front panel or with the optional Model 5802 IEEE-488 Interface. With the Model 5802 interface installed, the Model 580 can be calibrated much faster using an automated system. Both calibration procedures are presented here.

Calibration should be performed every 12 months. If any of the calibration procedures in this section cannot be performed properly, refer to the troubleshooting information in Section 5 of this manual. If the problem persists, contact your Keithley representative or the factory for further information.

3.2 CALIBRATION EQUIPMENT

The following equipment may be used to calibrate the Model 580 (alternate calibration equipment may be used if it is of equivalent accuracy):

2Ω-200kΩ Ranges—Fluke Model 5450A Resistance Calibrator.

200mΩ Range—0.19Ω 4-wire resistor, known to ±50ppm with ±20ppm/°C temperature coefficient.

In place of the Fluke 5450A, individual resistors that are 95% of the particular range to be calibrated and are known to ±50ppm (±20ppm/°C) may also be used.

The following companies supply low value (0.10Ω, 0.19Ω) resistors.

TEL LABS
154 Harvey Road
P.O. Box 375
Londonderry, NH 03053
(603) 625-8994

Vishay Resistive Systems Group
63 Lincoln Highway
Malvern, PA 19355
(215) 644-1300

Guildline Instruments Inc.
2 Westchester Plaza
Elmsford, NY
(914) 592-9101

Electro Scientific Industries, Inc.
13900 N.W. Science Park Drive
Portland, OR 97229
(503) 641-4141

3.3 ENVIRONMENTAL CONDITIONS

Calibration should be performed in an ambient temperature of 23°C ±3°C and a relative humidity of less than 70%. If the instrument has been subject to temperatures outside of this range, or to higher humidity, allow at least one additional hour for the instrument to stabilize before beginning the calibration procedure. Always allow at least one hour of warm-up time when calibrating the instrument over the IEEE-488 bus with the IEEE interface installed.

3.4 CALIBRATION SWITCH

The Model 580 is shipped from the factory with its rear-panel CALIBRATION switch in the DISABLED position. In this position, calibration constants cannot be stored when entered from the front panel or over the IEEE-488 bus. The switch must be moved to ENABLED to allow calibration constant storage (see Figure 3-1).

The CALIBRATION switch is located in the middle of the rear panel. Slide the switch to ENABLED. Now plug in the line cord and turn on the instrument. The Model 580 is now ready for calibration.

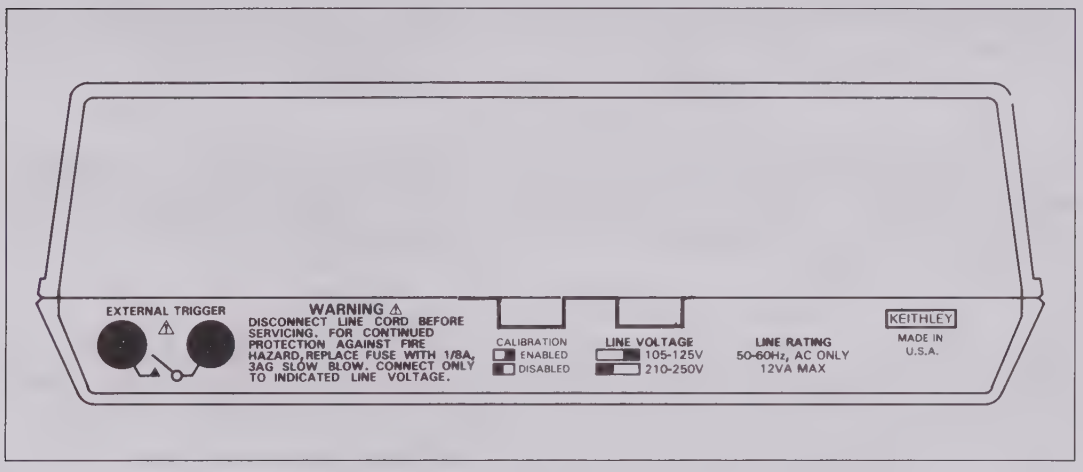


Figure 3-1. Calibration Switch on Rear Panel

3.5 FRONT PANEL CALIBRATION

Before starting the calibration procedure, check to ensure that the CALIBRATION switch is in the ENABLED position (see Figure 3-1). Also be sure that the instrument is in DRIVE (⎍⎍), POL+, and that line frequency is appropriately set (refer to Section 1.5). Connect calibration resistor to the Model 580 as shown in Figure 3-2.

Note: Calibration may be stopped at any time and, if desired, only selected ranges need be calibrated.

1. Press SHIFT and REL simultaneously and hold until "CAL" appears in the numeric field of the display (this takes about three seconds). Release SHIFT and REL. The CAL annunciator now appears on the far right side of the front panel display.

NOTE

The 200mΩ, 2Ω and 20Ω ranges in non-Dry Circuit Test must be calibrated prior to calibrating desired Dry Circuit Test ranges.

2. Now apply a known resistance to the first range to be calibrated, i.e., apply 190mΩ to the 200m range (see paragraph 3.2 for sources of calibration equipment). Adjust the display to read the exact resistance value applied by pressing POLARITY to decrease the reading or TRIG to increase the reading.
3. Go on to the next range and calibrate that range using the same method described in step 2.

4. After all desired ranges have been calibrated, lock in new calibration constants by pressing SHIFT and REL simultaneously and holding them until "Stor" appears (again, this will take about three seconds). The new calibration constants have now been permanently stored. (Note the calibration state has been exited, and the CAL annunciator is now off).

To ensure that calibration constants, once entered, cannot be changed, place the CALIBRATION switch in DISABLED. This is a "hard" lockout which prevents inadvertent miscalibration. Some users prefer to affix a calibration sticker over the switch opening. Do not cover WARNING information with this sticker.

To temporarily change calibration (valid until unit is powered off), slide the rear panel CALIBRATION switch to DISABLED and follow steps 1 through 4. This time the display will read "out" when calibration is exited. Note that the CAL annunciator is now flashing, indicating that calibration is temporary. Cycle ON/OFF switch to restore original calibration.

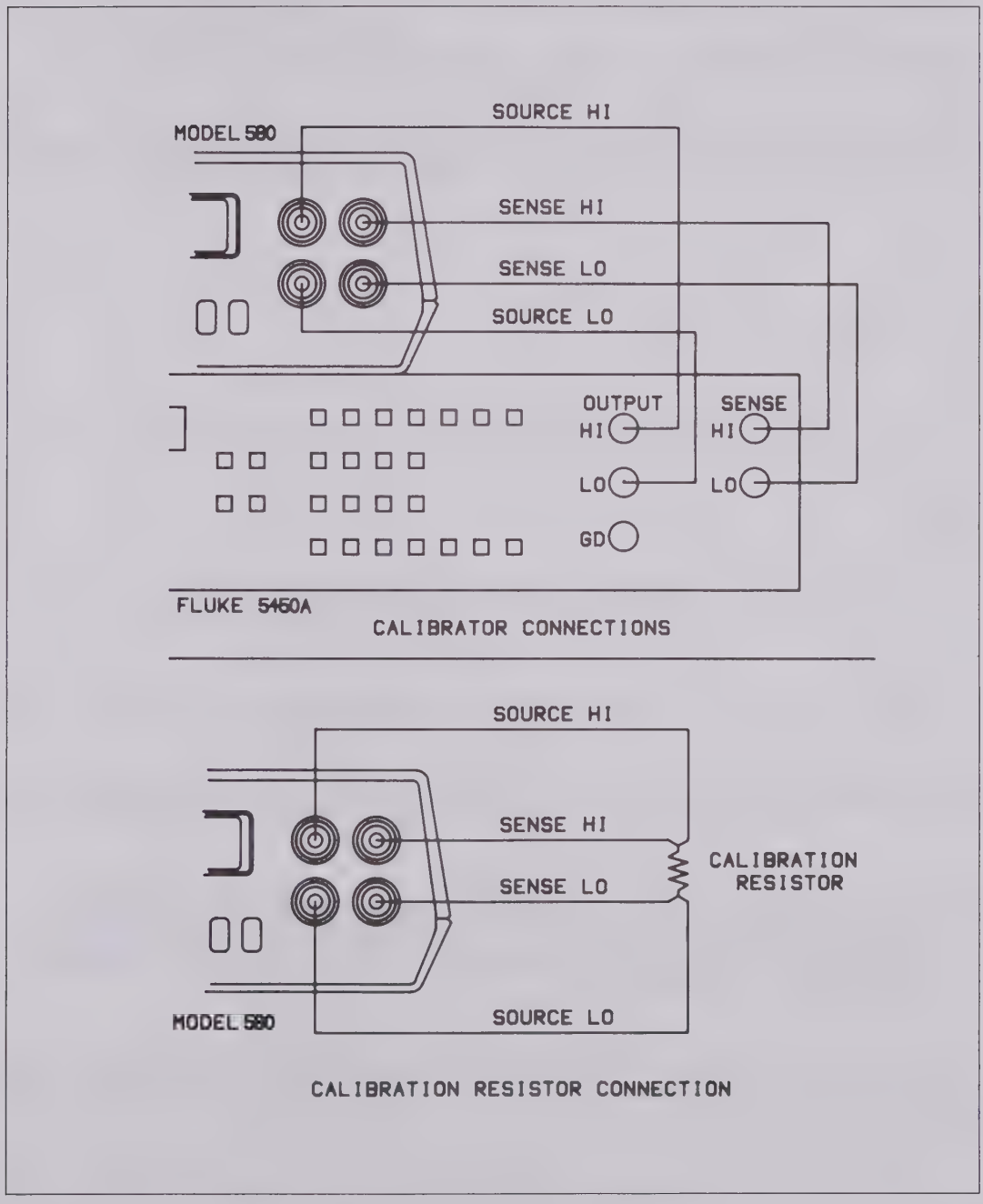


Figure 3-2. Four-Wire Resistance Calibration

3.6 CALIBRATION OVER THE IEEE-488 BUS WITH THE MODEL 5802

Calibration over the IEEE-488 bus can only be accomplished with the CALIBRATION switch in the ENABLED position (see paragraph 3.4 for more information about the CALIBRATION switch).

Through the use of the V command, the Model 580 enters the calibration mode and the calibration value is transmitted to the instrument. The calibration command is in the form:

V+/−n.nnnnE+/−nn

where:
+/−n.nnnn represents the mantissa (4½ digits)
E+nn represents the exponent.

The calibration values entered can be permanently stored through the use of the L0 command. This command also takes the Model 580 out of the calibration mode.

NOTES:

1. Only as many significant digits as necessary need to be entered. For example, for calibration of the 20Ω range with a 19.000 input value, the following command would be used:

   V19X

2. The correct calibration value must be connected to the instrument before the V command is sent.

Programming Example—The following shows a sample program for calibrating the 2Ω range of the Model 580 (with a Model 5802 interface installed) by an HP-85 computer over the IEEE-488 bus.

CAUTION
If the CALIBRATION switch is in the ENABLED position, DO NOT PERFORM THESE STEPS UNLESS CALIBRATION STORAGE IS DESIRED. Unless proper calibration parameters have been previously programmed, inadvertently using this command seriously affects instrument accuracy.

Using the front panel controls, place the instrument in the 2Ω range. Connect a known accurate resistor, such as a +1.9085Ω reference resistor, to the Model 580 test leads and enter the following statements into the HP-85 computer:

```
REMOTE 725
OUTPUT 725; ''V1.9085X''
OUTPUT 725; ''L0X''
```

When the END LINE key is pressed after the V1.9085X statement, the instrument calibrates itself in accordance with the applied input.

When the END LINE key is pressed after the L0X statement, calibration storage takes place. For more information on calibration over the IEEE-488 bus with the HP-85 computer or other controllers, see the Model 5802 Instruction Manual.

SECTION 4
Principles of Operation

4.1 INTRODUCTION

This section contains an overall functional description of the Model 580. Information pertaining to the optional Model 1978 Battery Pack is also included. While reviewing the principles of operation, it may be helpful to refer to the detailed schematic diagrams and component layout drawings located at the end of this manual.

4.2 OVERALL FUNCTIONAL DESCRIPTION

The Model 580 is a 4½ digit micro-ohmmeter with seven resistance ranges. A simplified block diagram of the Model 580 is shown in Figure 4-1.

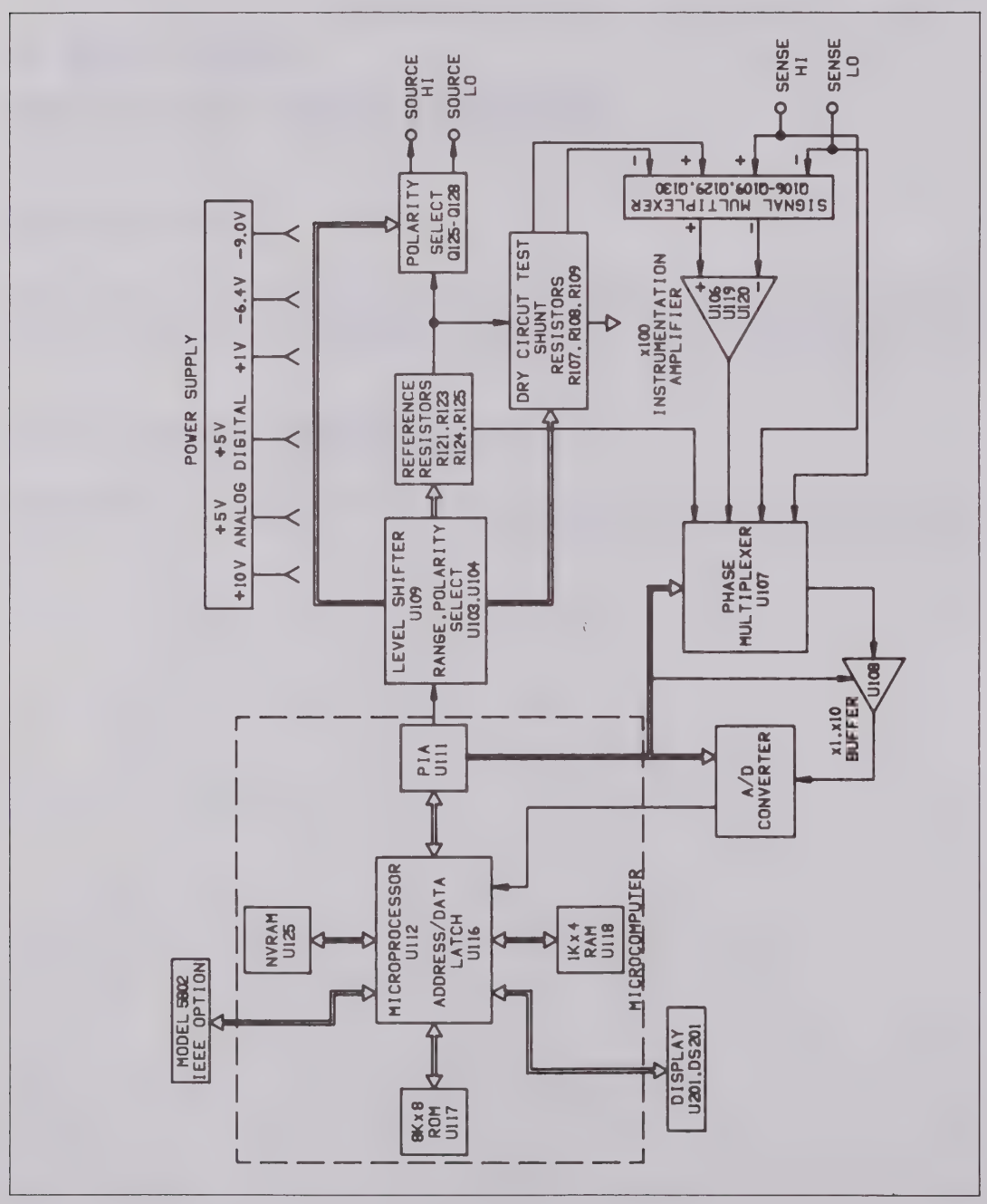
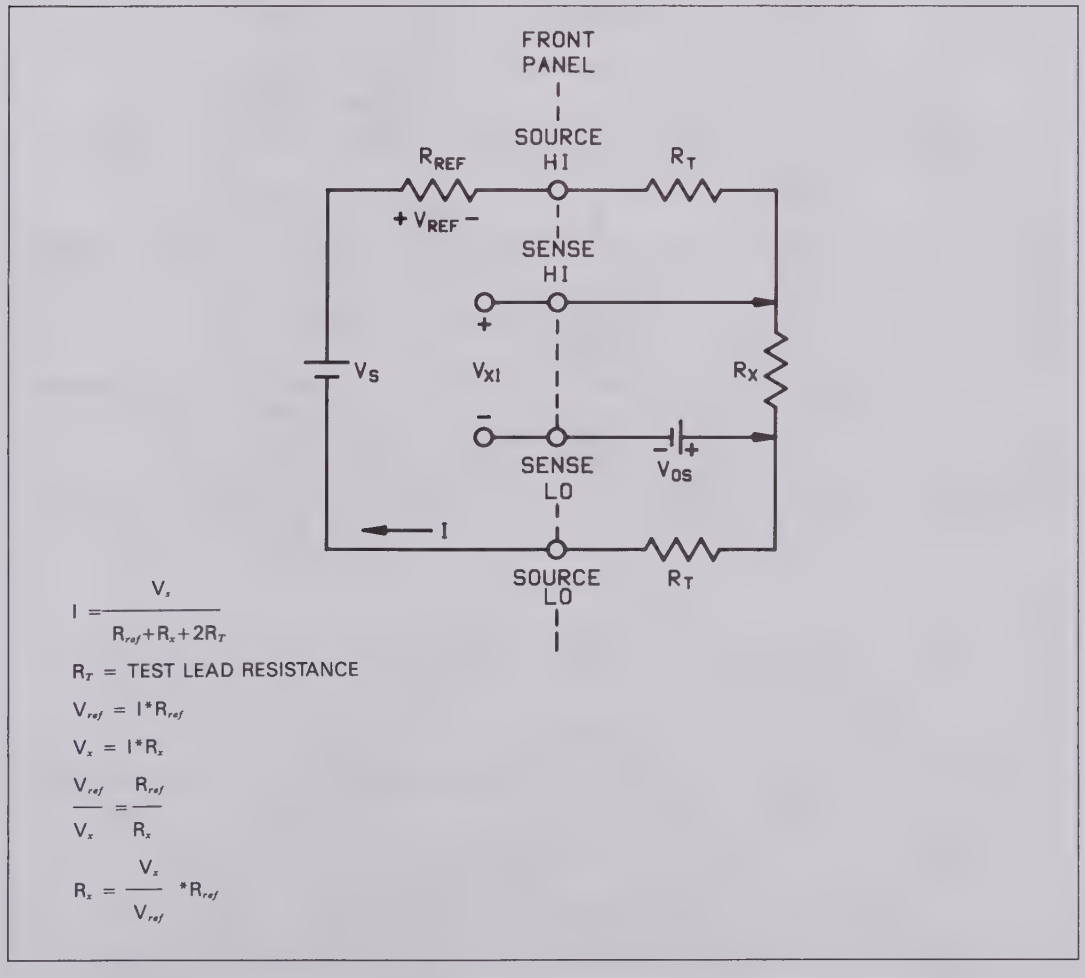


Figure 4-1. Simplified Block Diagram

4.3 ANALOG CIRCUITRY

4.3.1 Ratiometric Resistance Measurement

The Model 580 takes 4-wire resistance measurements. This method minimizes test lead resistance errors that normally occur with 2-wire resistance measurements. Measurement is performed using the ratiometric technique. A series circuit is formed between a voltage source (V_s), a reference resistor (R_{ref}), and the unknown resistor (R_x) (see Figure 4-2). The same current flows through both the reference and unknown resistors. Since R_{ref} is known, the value of R_x can be calculated by measuring the voltage across the reference and unknown resistors.



$$I = \frac{V_s}{R_{ref} + R_x + 2R_T}$$

R_T = TEST LEAD RESISTANCE

$V_{ref} = I * R_{ref}$

$V_x = I * R_x$

$$\frac{V_{ref}}{V_x} = \frac{R_{ref}}{R_x}$$

$$R_x = \frac{V_x}{V_{ref}} * R_{ref}$$

Figure 4-2. Ratiometric Resistance Measurement

The voltage source (V_s in Figure 4-2) can be either pulsed or DC depending on DRIVE selected. DC DRIVE allows current to pass through the unknown without interruption. In pulsed DRIVE, the current that passes through the unknown is cycled on and off at approximately 3Hz intervals. During both the on and off parts of the cycle the voltage across the unknown is measured. Ideally, when the current is off, the voltage across the unknown resistance should be zero. However, due to thermal emfs (voltages generated at the junctions of dissimilar metals) in the unknown resistor and test lead connections, voltage offsets (V_{os}) are present which could cause significant errors if not accounted for. The voltage measured across the unknown when the current is off is subtracted from the voltage measured when the current is on. This determines the voltage across R_x due to reference current. From this measurement, the value of R_x can be computed (see Figure 4-3).

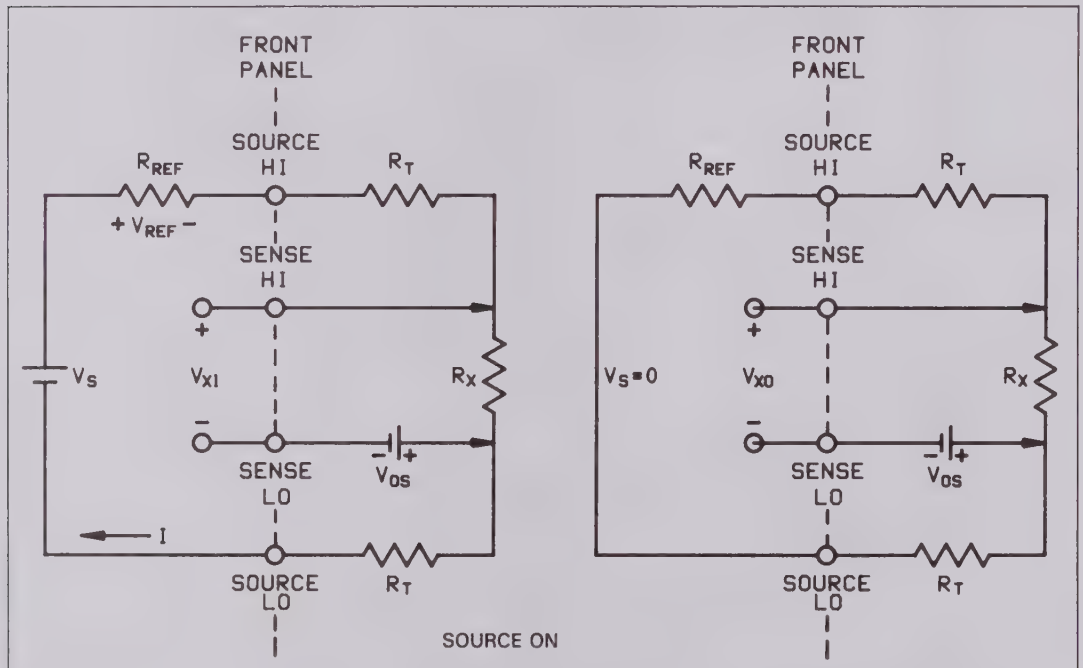
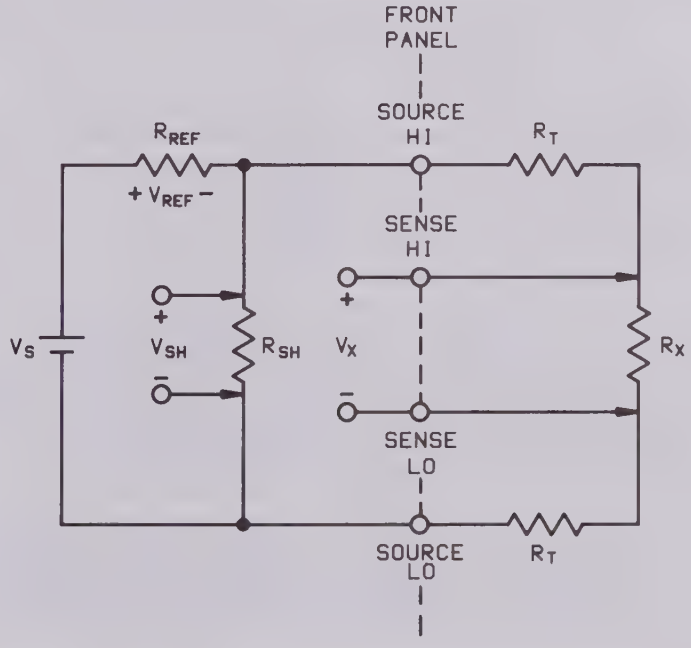


Figure 4-3. Pulsed DRIVE

In Dry Circuit Test, open circuit voltage must be kept below 20mV. To do this, a known resistor is switched in parallel with the unknown resistor being measured. Upon selecting dry circuit test one of three precision known resistors R_{sh} (R107, R108 or R109, depending on range) is internally connected between the SOURCE HI and SOURCE LO terminals, passively clamping the maximum SOURCE voltage to 20mV or less (see Figure 4-4). The voltage across R_{sh} is measured, and used to calculate R_x.



$$R_x = \frac{V_x - V_{xo}}{\frac{V_{ref}}{R_{ref}} - \frac{V_{sh} - V_{sho}}{R_{sh}}}$$

where V_{xo} and V_{sho} are V_x and V_{sh} taken with V_x=0.

Figure 4-4. Dry Circuit Test Resistance Measurement

4.3.2 Signal Conditioning

The Model 580 uses four reference resistors to cover its seven decades of resistance (see Table 4-1). The microprocessor selects the proper reference resistor by connecting the high side of the reference resistor to the +1V source via MOSFET switch Q116, Q119, Q120 or Q121. The MOSFETs are driven by U104 with either 0V (FET off) or +10V (FET on). U104 receives its serial data from the microprocessor through level shifter U109.

Table 4-1. Model 580 Reference Resistors

Range	Reference Resistor
200mΩ	R123
2 Ω	R121 + R123
20 Ω	R125
200 Ω	R125
2 kΩ	R125
20 kΩ	R124
200 kΩ	R124

The reference voltage (V_{ref}) for all ranges and the voltage developed across R_x for the 200Ω-200kΩ ranges is determined by taking two measurements, one on each side of R_{ref} or R_x. The difference is taken between the two measurements to determine the voltage across R_x or R_{ref}. Measurement of the voltages developed across R_x and R_{sh} on the 200mΩ-20Ω ranges is done using the instrumentation amplifier consisting of U106, U119, U120, R126, R127, R129 and R130.

The instrumentation amplifier is configured to give a voltage gain of 100. Voltage measurement selection between V_x and V_{sh} is done by the signal multiplexer comprised of Q129, Q130 and Q106 through Q109. For measurement of V_x , Q129 and Q130 are turned on while Q106 through Q109 are turned off. For measurement of V_{sh} , Q129 and Q130 are turned off while Q107 and either Q106, Q108 or Q109 are turned on.

The gate drive for Q129 and Q130 is provided by U127 and CR104. They are configured to maintain the gate to drain voltage of Q129 and Q130 to less than 50mV when Q129 and Q130 are on.

The phase multiplexer U107 selects between the signals that make up the Model 580's measurement cycle. The input buffer amplifier (U108) provides isolation between the input signal and the A/D converter. The amplifier provides X1 or X10 gain depending on the range selected. X1 or X10 is selected by turning Q113 off or on, respectively.

4.3.3 A/D Converter

The Model 580 uses a combination constant frequency, variable pulse width, charge balance and single slope A/D converter. A simplified schematic of the A/D used in the Model 580 is shown in Figure 4-5.

The Charge Balance phase begins when the input enable line (pin 9 of U121B) is set high. Once the input is enabled, the signal from the buffer amplifier is added to the level shift current applied through R134. This ±2V bipolar signal from the buffer amplifier is converted to a unipolar signal that can be integrated.

The integrator consists of Q133, U122, C127 and associated components. When the input to the integrator is applied (Q123 conducting), the integrator output ramps up until it passes the charge balance comparator (U124B) threshold voltage (+5V). When the Q3 output of the clock generator (U123) goes high and the output of U110A is low, the $\overline{Q1}$ output of U121A will go high. This action injects a known current into the integrator input. Since this Charge Balance current is much larger than the sum of the input current plus the level shifting current, the integrator output ramps in the negative direction. The integrator output continues to ramp in the negative direction until the output of U110B goes low. The length of time that $\overline{Q1}$ of U121A remains high depends on the state of the Charge Balance comparator output U124B when Q3 of U123 goes high. Thus, the charge injected is proportional to the input voltage. Each time the U121A output goes high, it is gated (internal to the microprocessor) with the microprocessor's clock and its pulses are counted. Charge Balance lasts from 16 to 40msec, depending on range selected. At the end of Charge Balance, the integrator rests at some positive voltage. During Single Slope, Q123 is turned off, disconnecting the input and charge balance currents from the integrator input. Single slope current is then applied to the integrator input. This current is generated by connecting R136 to +5V through U115C. The single slope comparator output (U124A) is gated with the microprocessor's internal clock, and pulses are counted. Once U124A goes low, the microprocessor stops counting and one phase measurement is complete. Three to six phases are needed for one reading, depending on the range and features selected. Two additional phases are taken to detect open sense leads.

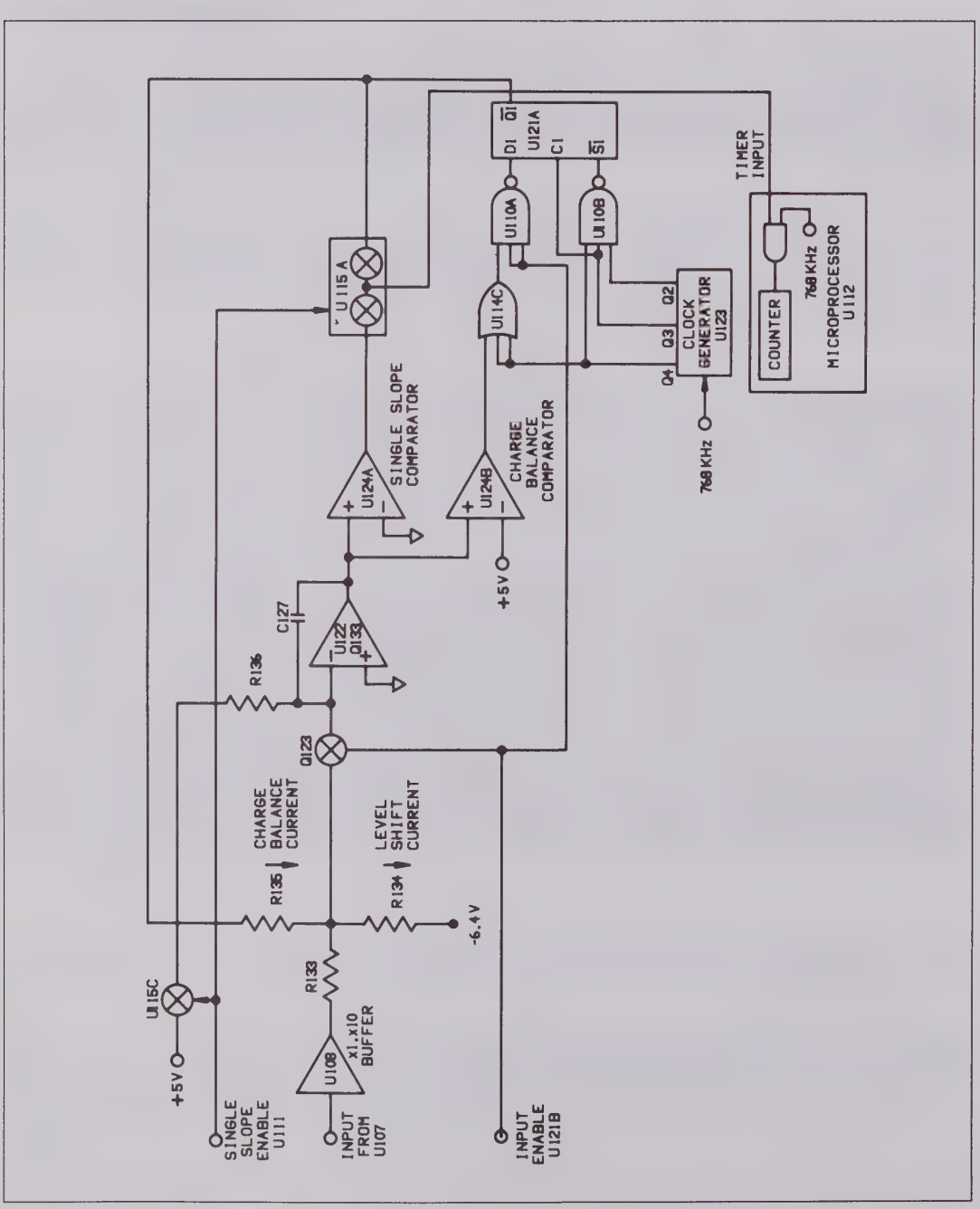


Figure 4-5. A/D Converter Schematic

4.3.4 Protection

Overload protection on the SOURCE terminals is accomplished by Q124 through Q128, CR102 and R144. During a positive overload the internal source-to-drain diode of Q127 is forward biased. Once the voltage at the Q125 drain rises to 2.8V, CR102 and the source-to-drain diodes of Q124 and Q126 become foward biased, shunting the overload current to SOURCE LO. For a negative overload, the internal source-to-drain diodes of Q125 and Q128 are forward biased. As the overload current continues to flow, RT101 changes from low resistance (0.1Ω) to high resistance (>1kΩ), limiting the input overload current. Overload protection on the SENSE terminals is provided by R149, R150, Q131 and Q132. Resistors R149 and R150 limit the input overload currents while Q131 and Q132 clamp the input voltage of the sensing circuitry to a safe limit.

4.3.5 Polarity

Polarity selection is accomplished by Q125 through Q128, configured in an "H" bridge. For positive output polarity, Q126 and Q127 are on while Q125 and Q128 are off. For negative output polarity, Q125 and Q128 are on while Q126 and Q127 are off.

4.4 DIGITAL CIRCUITRY

Model 580 operation is controlled by an internal microcomputer. This section briefly describes the operation of the various sections of the microcomputer and its associated digital circuitry. For more complete circuit details, refer to schematic diagram 580-106 at the end of this manual.

4.4.1 Microcomputer

The microcomputer is based on the 146805E2 CMOS microprocessor (U112) which has direct addressing of up to 8K bytes on a shared address and data bus. Multiplexing of the address and data bus is accomplished using U116.

A 3.84MHz crystal, Y101, is the precision time base for the instrument. Internally the 3.84MHz clock is divided by U112 to obtain a bus operating frequency of 768kHz which is present on the address strobe of U112 (pin 6) and supplies timing to all other parts of the instrument through the binary divider U123.

Firmware for the microprocessor is stored in U117, an 8k x 8 PROM. Temporary storage is provided by U118, a 1k x 4 RAM. The microprocessor uses U118 as temporary storage of the microprocessor in-house functions and as temporary calibration storage. During power-up the NVRAM data is transferred to U118 to allow easier access during operation. Data transmission to the ROM, RAM and PIA (U111) is done in parallel. NVRAM data transmission is done serially. Address decoding is performed by U110, U113 and U114. See Table 4-2 for the Model 580 memory map.

The microprocessor has control over the display, front panel switches, A/D converter, and external trigger input either directly or through U111. U111 provides communication between the Models 580 and 5802 (IEEE-488 option), A/D control and additional I/O lines for range and reading control.

Table 4-2. Model 580 Memory Map

Device	Address Range
MPU (U112)	0000-007F
PIA (U111)	0080-00FF
RAM (U118)	0100-01FF
ROM (U117)	0200-1FFF

4.4.2 Display Circuitry

The triplexed LCD display is driven by a flat pack LCD controller chip, U201. It communicates to the microprocessor through four control lines: clock (SCK), data (SI), strobe (CS) and command/data select (C/D). The U201 is updated approximately three times per second depending on range and features selected. The frame frequency for the display is 65Hz.

Four voltages (+5V, +3.33V, +1.66V, 0V) are supplied from R118 to bias the LCD controller (U201). The clock required by U201 is obtained from U123.

4.5 POWER SUPPLY

AC power is brought into the Model 580 through plug J1006, T103 (common mode choke), F101 and S102. Switch S102 provides selection of 115VAC or 230VAC operation by placing the power transformer (T101) windings in parallel (115V) or series (230V). Transformer T101 has two secondary windings that supply power to the Models 580 and 5802 (analog output/IEEE-488 option). The output of T101 supplies power to diode bridge rectifier CR101 which acts as a full wave rectifier for the positive and negative voltage supplies of the Model 580.

Six different DC supply voltages (+10V, +5V analog, +5V digital, +1V, -6.4V, -9V) are generated for use within the instrument. Prefiltering for the positive and negative supplies is accomplished by R112, R117, VR104 and VR105. The +10V supply must be operating for the other positive supply voltages to operate properly. The +10V supply is generated by the discrete voltage regulator composed of VR101, U101, Q102, R101 and C109. This configuration provides constant current through VR101, making the +10V supply insensitive to pre-regulator supply voltage variations. The +5 analog and +5 digital supplies are generated by U105, Q101 and Q112. The reference for the +5V supplies is provided by R104 and R105 which divide the reference voltage (6.35V) across VR101 to +5V.

The +1V supply is used as the excitation voltage for measuring the unknown resistance. It is generated by a DC to DC converter composed of Q104, Q105, Q110, Q111 and T102. Clock drive (48kHz) for Q104 and Q105 is provided by U113C and U113D. Transistors Q110 and Q111, driven by T102, act as a synchronous rectifier which converts the output of T102 from +1V 48kHz square wave to +1V DC. Filtering is accomplished by L101 and C108.

The -6.4V and -9V supply voltages are generated by the discrete voltage regulator consisting of VR102, U102, Q103 and R101. The configuration is identical to the +10V supply to provide low noise and drift.

4.6 MODEL 1978 BATTERY PACK OPTION

The 1978 Battery Pack option includes a 12V, 500mAh nickel cadmium rechargeable battery, low voltage detection circuit and voltage inverter circuit.

The maximum charging rate (150mA) is achieved when the instrument is connected to line power and the ON/OFF switch is off. Full-wave rectified voltage from CR101 is applied to R117 and BT101 to charge the batteries. Q101 acts as a current sink to limit the charging current to 150mA. The batteries are the quick recharge type and will charge in eight to 10 hours. When the instrument is turned on, the batteries will trickle charge at approximately 40mA, which increases the charging time to 20 hours.

When the battery is installed and the instrument is turned on, negative supply is generated by the CMOS voltage inverter (U101). The inverter output is filtered by CR101 and C101.

Low battery detection is performed by the comparator (U102) and the microprocessor. A voltage level of 11.6V across BT101 signals need to recharge battery. The trip level for the comparator is set by R103 and R104.

SECTION 5
Troubleshooting

5.1 INTRODUCTION

The troubleshooting instructions contained in this section are intended for use by qualified personnel having a basic understanding of analog and digital circuitry. The individual should also be experienced at using electronic test equipment as well as standard troubleshooting procedures. The information presented here has been written to assist in isolating a defective circuit or circuit section; isolation of the specific component is left to the technician.

The success or failure in troubleshooting an instrument such as the Model 580 depends not only on the skill of the technician, but also relies on the use of appropriate test equipment. Table 5-1 lists the required test equipment and specifications recommended for troubleshooting the Model 580.

Table 5-1. Recommended Troubleshooting Equipment

Equipment	Use
Five function DMM with 0.1% basic DCV accuracy, 10MΩ input impedance.	Power supply and DC voltage checks; analog signal tracing continuity, logic levels.
Dual-trace, triggered sweep oscilloscope, DC to 50MHz.	Digital and analog waveform measurements.
Digital Frequency Counter	Checking clock frequencies.

5.2 POWER UP SEQUENCE

The software revision level of the Model 580 may be displayed upon power-up by running the diagnostic program. The diagnostic program is explained in paragraph 5.3.

When the Model 580 is turned on it goes through a power-up sequence that is outlined as follows:

1. The line frequency is briefly displayed (F50 or F60).
2. A RAM and NVRAM test is performed before the Model 580 begins taking measurements.
3. If the RAM test fails, the Model 580 locks up with all zeroes. Refer to Table 2-1 of the Operator's Manual.

4. If the NVRAM test fails, the following message is displayed:

cErr

5. If no problem is found by the RAM and NVRAM checks, the Model 580 begins taking measurements.

If the RAM check reveals a problem, check U118. If the NVRAM check reveals a problem, check U125 and refer to paragraph 5.3 (NVRAM test).

5.3 SELF DIAGNOSTIC PROGRAM

The self diagnostic program is designed to aid the technician in troubleshooting the Model 580. There are several tests that may be performed using the self diagnostic program. These tests (display, software revision level and sequential display test) are run automatically. After this sequence the Model 580 enters troubleshooting diagnostics.

To enter the self diagnostic program, press and hold in the REL button while turning on the Model 580. The following sequence occurs:

1. The line frequency setting (F50 or F60) is briefly displayed.
2. All LCD digits and annunciators turn on.
3. The software revision level is then displayed (e.g. A1).
4. The sequential display test runs.
5. The Model 580 begins troubleshooting diagnostics.

If the REL button is released before completing the sequential display test, the instrument flags either RAM or NVRAM self test failures, should they occur. If neither RAM nor NVRAM fails, the instrument enters troubleshooting diagnostics.

RAM Test—If the RAM test fails, the Model 580 locks up with all zeroes displayed. Replacing U118 may correct the problem.

Non-Volatile RAM Test—If the NVRAM test fails, the following message is displayed:

cErr

This is a message indicating that the instrument is probably no longer properly calibrated, since calibration constants are stored in NVRAM. The Model 580 remains at this point if the test fails, but operation may be restored for troubleshooting by pressing SHIFT, TRIG, or POLARITY. (If REL is pressed, the Model 580 will begin self diagnostics.) The flashing CAL annunciator indicates that the unit failed the NVRAM test.

At this point, try calibrating the instrument with the constants already entered by simultaneously pressing REL and SHIFT until the CAL message is displayed. Then release the REL and SHIFT buttons. Set rear panel calibration switch to ENABLED. Simultaneously press the REL and SHIFT buttons again until "Stor" is displayed. If the error is corrected, indicating that the NVRAM is probably good, a full calibration is required. If the error persists, try replacing the NVRAM chip, U125. Again the Model 580 must be completely recalibrated after the problem is corrected.

Sequential Display Test—Segments and annunciators are sequentially displayed in eight steps. Use Figure 5-1 for segment identification. The steps are as follows:

1. The "a" segments of the digits, DRIVE (⎍⎍), and CIRCUIT are displayed.
2. The "b" segments of the digits and ⎓ are displayed.
3. The "c" segments of the digits and the left-most "1" are displayed.
4. The "d" segments, REL, LLO and RMT are displayed.
5. The "e" segments, "m", AUTO, and POL minus sign are displayed.
6. The "f" segments, DRY, TEST, and part of the vertical segment of the POL plus sign.
7. The "g" segments, ohm sign, CAL, POL and mantissa minus sign are displayed.
8. "kΩ", BAT, TRIG, the remaining segment of the POL plus sign, and decimal points are displayed.

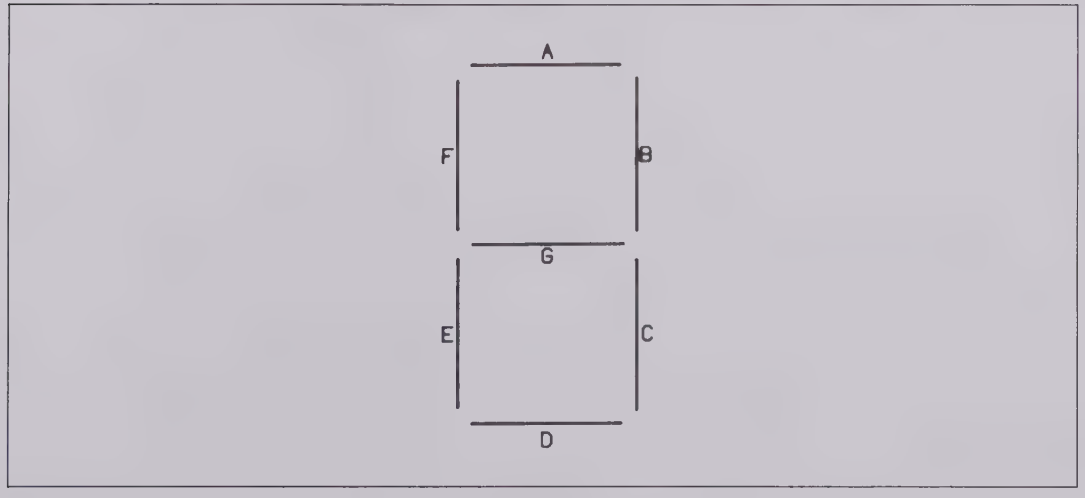


Figure 5-1. Segment Identification

Troubleshooting Diagnostics—The troubleshooting diagnostics are designed to switch on various FETs, transistors, relays and logic levels to allow signal tracing through the instrument. The displayed message reflects the selected function and range. For example, assume that "0o3" is displayed.

In this case,

0 is the phase.
o is a placeholder.
3 corresponds to the 200Ω range.

The test number can be changed by pressing the REL button. Table 5-2 lists test for all ranges.

5.4 SIGNAL CONDITIONING

A full dynamic measurement can be broken down into a sequence of hardware states, called phases. Each phase consists of a unique assignment of multiplexer channels and amplifier gains. With the troubleshooting diagnostics, it is possible to stop the dynamic measurement and sequentially step through each phase.

By pressing REL, the instrument will toggle through the different phases used to determine a reading. This way, signals may be traced through the analog circuitry. Table 5-2 shows the output signals of U103, U104 and U111 used to take a measurement. Table 5-2 shows range and phase as described by the Model 580 front panel and display and outputs of U103, U104 and U111 for the measurement. A "1" indicates a logic high of +5 or +10V and a "0" indicates a logic low of zero volts. The outputs of U103 and U104 are used for range and function selection.

Table 5-2. Model 580 Troubleshooting Diagnostics

POL+, DRIVE (⎍⎍)																
		U104								U103				U111			
Range	Phase	Q_8	Q_7	Q_6	Q_5	Q_4	Q_3	Q_2	Q_1	Q_6	Q_5	Q_4	Q_3	PB3	PB2	PB1	PB0
200mΩ	0o0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1
	1o0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
	4o0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0
	5o0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0
	6o0	1	0	0	1	0	0	0	0	1	1	1	1	0	1	0	1
	7o0	1	0	0	1	0	0	0	0	1	1	1	1	0	0	0	1
2 Ω	0o1	0	0	0	0	0	0	1	0	1	1	1	1	1	1	1	1
	1o1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
	4o1	0	0	0	0	0	0	1	0	1	1	1	1	1	1	0	0
	5o1	0	0	0	0	0	0	1	0	1	1	1	1	1	1	1	0
	6o1	1	0	0	1	0	0	0	0	1	1	1	1	0	1	0	1
	7o1	1	0	0	1	0	0	0	0	1	1	1	1	0	0	0	1
20 Ω	0o2	0	0	0	0	0	1	0	0	1	1	1	1	1	1	1	1
	1o2	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
	4o2	0	0	0	0	0	1	0	0	1	1	1	1	1	0	1	1
	5o2	0	0	0	0	0	1	0	0	1	1	1	1	1	1	1	0
	6o2	1	0	0	1	0	0	0	0	1	1	1	1	0	1	0	1
	7o2	1	0	0	1	0	0	0	0	1	1	1	1	0	0	0	1
200 Ω	0o3	1	0	0	0	0	1	0	0	0	0	1	1	0	1	0	1
	1o3	1	0	0	0	0	1	0	0	0	0	1	1	0	0	0	1
	2o3	1	0	0	0	0	0	0	0	0	0	1	1	0	1	0	1
	3o3	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1
	4o3	1	0	0	0	0	1	0	0	0	0	1	1	1	0	1	1
	5o3	1	0	0	0	0	1	0	0	0	0	1	1	1	1	1	0
	6o3	1	0	0	1	0	0	0	0	1	1	1	1	0	1	0	1
	7o3	1	0	0	1	0	0	0	0	1	1	1	1	0	0	0	1
2 kΩ	0o4	1	0	0	0	0	1	0	0	0	0	1	1	1	1	0	1
	1o4	1	0	0	0	0	1	0	0	0	0	1	1	1	0	0	1
	2o4	1	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1
	3o4	1	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1
	4o4	1	0	0	0	0	1	0	0	0	0	1	1	1	0	1	1
	5o4	1	0	0	0	0	1	0	0	0	0	1	1	1	1	1	0
	6o4	1	0	0	1	0	0	0	0	1	1	1	1	0	1	0	1
	7o4	1	0	0	1	0	0	0	0	1	1	1	1	0	0	0	1

Table 5-2. Model 580 Troubleshooting Diagnostics (Cont.)

		POL+, DRIVE (⎍)															
		U104								U103				U111			
Range	Phase	Q_8	Q_7	Q_6	Q_5	Q_4	Q_3	Q_2	Q_1	Q_6	Q_5	Q_4	Q_3	PB3	PB2	PB1	PB0
20 kΩ	0o5	1	0	0	0	1	0	0	0	0	0	1	1	0	1	0	1
	1o5	1	0	0	0	1	0	0	0	0	0	1	1	0	0	0	1
	2o5	1	0	0	0	0	0	0	0	0	0	1	1	0	1	0	1
	305	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1
	4o5	1	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0
	5o5	1	0	0	0	1	0	0	0	0	0	1	1	1	1	1	0
	6o5	1	0	0	1	0	0	0	0	1	1	1	1	0	1	0	1
	7o5	1	0	0	1	0	0	0	0	1	1	1	1	0	0	0	1
200 kΩ	0o6	1	0	0	0	1	0	0	0	0	0	1	1	1	1	0	1
	1o6	1	0	0	0	1	0	0	0	0	0	1	1	1	0	0	1
	2o6	1	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1
	3o6	1	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1
	4o6	1	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0
	5o6	1	0	0	0	1	0	0	0	0	0	1	1	1	1	1	0
	6o6	1	0	0	1	0	0	0	0	1	1	1	1	0	1	0	1
	7o6	1	0	0	1	0	0	0	0	1	1	1	1	0	0	0	1
		DRY CIRCUIT TEST, POL+, DRIVE (⎍)															
200mΩ	0o0	0	0	0	1	0	0	0	1	1	1	1	1	1	1	1	1
	1o0	0	0	0	1	0	0	0	0	1	1	1	1	1	1	1	1
	2o0	1	0	0	1	0	0	0	1	0	1	1	0	1	1	1	1
	3o0	1	0	0	1	0	0	0	0	0	1	1	0	1	1	1	1
	4o0	0	0	0	1	0	0	0	1	1	1	1	1	1	1	0	0
	5o0	0	0	0	1	0	0	0	1	1	1	1	1	1	1	1	0
	6o0	1	0	0	1	0	0	0	0	1	1	1	1	0	1	0	1
	7o0	1	0	0	1	0	0	0	0	1	1	1	1	0	0	0	1
2 Ω	0o1	0	0	1	0	0	0	1	0	1	1	1	1	1	1	1	1
	1o1	0	0	1	0	0	0	0	0	1	1	1	1	1	1	1	1
	2o1	1	0	1	0	0	0	1	0	0	1	0	1	1	1	1	1
	3o1	1	0	1	0	0	0	0	0	0	1	0	1	1	1	1	1
	4o1	0	0	1	0	0	0	1	0	1	1	1	1	1	1	0	0
	5o1	0	0	1	0	0	0	1	0	1	1	1	1	1	1	1	0
	6o1	1	0	1	0	0	0	0	0	1	1	1	1	0	1	0	1
	7o1	1	0	1	0	0	0	0	0	1	1	1	1	0	0	0	1

Troubleshooting consists of selecting the desired test and using the data found in Table 5-2 to signal trace the circuit.

Table 5-2. Model 580 Troubleshooting Diagnostics (Cont.)

DRY CIRCUIT TEST (cont.)																
		U104								U103				U111			
Range	Phase	Q_8	Q_7	Q_6	Q_5	Q_4	Q_3	Q_2	Q_1	Q_6	Q_5	Q_4	Q_3	PB3	PB2	PB1	PB0
20 Ω	0o2	0	1	0	0	0	1	0	0	1	1	1	1	1	1	1	1
	1o2	0	1	0	0	0	0	0	0	1	1	1	1	1	1	1	1
	2o2	1	1	0	0	0	1	0	0	0	0	1	1	1	1	1	1
	3o2	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1
	4o2	0	1	0	0	0	1	0	0	1	1	1	1	1	0	1	1
	5o2	0	1	0	0	0	1	0	0	1	1	1	1	1	1	1	0
	6o2	1	1	0	0	0	0	0	0	1	1	1	1	0	1	0	1
	7o2	1	1	0	0	0	0	0	0	1	1	1	1	0	0	0	1

Troubleshooting consists of selecting the desired test and using the data found in Table 5-2 to signal trace the circuit.

5.5 POWER SUPPLY AND BATTERY PACK (MODEL 1978)

Table 5-3 shows the various checks that can be made to the power supplies of the Models 580 and 1978. In addition to the normal voltage checks, it is a good idea to inspect the various supplies with an oscilloscope for signs of noise or oscillations.

Table 5-3. Power Supply and Battery Pack Checks (1978)

NOTE
All measurements are referenced to Pin 2 of J1008.

Step	Item/Component	Required Condition	Remarks
1	S102	Set to 115V or 230V as required.	S102 is externally accessible from rear panel.
2	F102 Line Fuse	Continuity	
3	Line Cord	Plugged into proper line receptacle; power on.	
4	Power ON/OFF switch pin 3	+13V to +16.5V	+V power for regulator circuitry.
5	U101 pin 2	+6.4 ±5%	Inverting input for U101
6	U101 pin 3	+6.4 ±5%	Low noise positive supply reference.
7	Q101 collector and U105 pin 7	+10V ±5%	+10V supply
8	Power ON/OFF switch pin 6	−18V	−V power for regulator circuitry.
9	U102 pin 2	−6.4V ±10%	Inverting input for U102.
10	U102 pin 3	−6.4V ±10%	Low noise negative supply reference.
11	Q103 emitter	−9.0V, ±5%	−9V supply
12	U105 pin 3	+5V ±5%	+5V supply reference
13	U105 pin 2	+5V ±5%	Inverting input for U116.
14	Q101 emitter	+5.0V ±5%	+5V analog supply.
15**	Q112 emitter or J1009 pin 7	+5.0V ±10%	+5V digital supply.
16*	Q101 base	0.6V while charging. Power switch off. Line power connected.	Current sink
17*	U101 pin 8	>10.8V line cord disconnected, battery pack charged and power on.	Battery
18*	U102 pin 7	+5V with batteries charged.	Low battery detect comparator
19*	Anode of CR101	Within ±0.5V of U101 pin 8, but negative.	Voltage inverter output.

*Battery option (1978) checks.
**If Q112 is replaced, be sure that the device is properly seated on the mother board so that it will not touch the IEEE-488 board (if installed).

5.6 A/D CONVERTER AND DISPLAY

Make sure the A/D converter, microprocessor and display are operating properly BEFORE attempting to troubleshoot the signal conditioning circuits. Audit these circuits using the information in Tables 5-4, 5-5, and 5-6.

Table 5-4. Display Board Checks

Step	Item/Component	Required Condition	Remarks
1		Turn on power. Select range and input for on range reading.	
2		96kHz	
3	U201, pin 52	96kHz	Clock
4	U201, pin 9	0 to 5V pulses	Data
5	U201, pin 10	0 to 5V pulses	Strobe, chip select of LCD controller
6	U201, pin 7	+5V	Power to LCD controller
7	U201, pin 6	Ground	
8	U201, pin 3	+3.3V	Triplex Display Voltage
9	U201, pin 4	+1.66V	Triplex Display Voltage
10	U201, pin 13	Logic Low	Reset to LCD controller

Table 5-5. A/D Converter Checks

Step	Item/Component	Required Condition	Remarks
1		Turn power on, select range and resistor giving on scale reading.	
2	U112, pin 38	3.84MHz	Crystal Frequency (Y101)
3	U123, pin 10	768.0kHz Clock	Address strobe, system timing
4	U123, pin 12	1.50kHz	Microprocessor timing interrupt
5	U114, pins 12, 13	48kHz	A/D timing
6	U110B, pin 4	96.0kHz	A/D LCD timing
7	U121A, pin 4	48.0kHz, signal HI for 18.2μsec.	A/D timing
8	U115A, pin 2	Variable pulse train, signal HI for 2.6 μsec or 13μsec.	Charge balance input to microprocessor.
9	R134	Check for −6.4V on one end	
10	Q122, Gate	0V to −9V pulse train	
11	Q123, Gate	0V to −9V pulse train	
12	U122, pin 6		Integrator waveform
13	U124B, pin 7	+5V to 0V pulse train	Charge balance comparator output.
14	U124A, pin 1	+5V to 0V pulse train	Single slope comparator output.
15	U121B, pin 9	+5V to 0V pulse train	Integrator charge balance control.

Table 5-6. Microprocessor Checks

Step	Item/Component	Required Condition	Remarks
1		Turn on power, select range and resistor giving on scale reading.	
2	U112, pin 38	3.84MHz	Crystal frequency (Y101)
3	U111, pin 25	768kHz	Data strobe
4	U116, pin 11	768kHz	Address strobe
5	U123, pin 1	187Hz	Reset clock
6	U112, pin 1	+5V Logic level signal	Microprocessor reset
7	U111, pin 34	+5V Logic level signal	
8	U126A, pin 3	4V ±10%	
9	U126B, pin 6	1V ±10%	

5.7 SPECIAL HANDLING OF STATIC-SENSITIVE DEVICES

CMOS and MOS devices are designed to operate at very high impedance levels for low power consumption. As a result, any normal static charge that builds up on your person or clothing may be sufficient to destroy these devices if they are not handled properly. In Section 6, all CMOS and MOS devices in the parts list are marked with asterisks to designate them as static-sensitive devices. When handling these devices, use the following precautions to avoid damaging them.

1. The devices marked with asterisks on the parts list should be transported and handled only in containers specially designed to prevent static build up. Typically, these devices will be received in static-protected containers. The parts should remain there until ready for installation.
2. Remove the devices from their protective containers only at a properly grounded work station. Always ground yourself with a suitable wriststrap.
3. Handle the devices only by the body. Do not touch the pins.
4. Any printed circuit board into which the device is to be inserted must also be grounded to the bench or work station.
5. Use only grounded solder suckers.
6. Use only a grounded soldering iron.
7. Once the device is installed on the PC board, the device is adequately protected and normal handling may resume.

SECTION 6
Replaceable Parts

6.1 INTRODUCTION

This section contains replacement parts information, component location drawings and schematic diagrams for the Model 580 and Model 1978.

6.2 REPLACEABLE PARTS

Parts are listed alphanumerically in order of the schematic designation. The parts lists are integrated with the component location drawings and schematic diagrams for the respective circuit boards. Table 6-1 contains parts list information for the mother board. Table 6-2 contains parts list information for the display board. Parts list information for the optional Model 1978 Battery Pack is contained in Table 6-3.

6.3 TEST PROBE ACCESSORIES

If additional rubber bands or spring loaded probe tips are required for included Models 5804 Kelvin Test Lead Set, 5805 Kelvin Test Probes, and 5806 Kelvin Clip Lead Set, order part number GS-22 (eight rubber bands) or part number CS-551 (eight spring loaded probes).

6.4 ORDERING INFORMATION

To place an order, or to obtain information concerning replacement parts, contact your Keithley representative or the factory. See the inside front cover for addresses. When ordering include the following information:

1. Instrument Model Number
2. Instrument Serial Number
3. Part Description
4. Circuit Designation (if applicable)
5. Keithley Part Number

If an additional service manual is required, order the manual package (Keithley Part Number 580-902-01). The manual package includes an instruction manual and all pertinent addenda.

6.5 FACTORY SERVICE

If the instrument is to be returned to the factory for service, carefully pack the unit and include the following:

1. Complete the service form which follows this section and return it with the instrument.
2. Advise as to the warranty status of the instrument (see the inside front cover for warranty information).
3. Write the following on the shipping label: ATTENTION REPAIR DEPARTMENT.

6.6 SCHEMATIC DIAGRAMS AND COMPONENT LOCATION DRAWINGS

The component location drawings and schematic diagrams are presented as follows:

Figure 6-3. Mother Board, Component Location Drawing

Figure 6-4. Mother Board, Schematic Drawing

Figure 6-5. Display Board, Component Location Drawing

Figure 6-6. Display Board, Schematic Diagram

Figure 6-7. Model 1978 Battery Pack, Component Location Drawing

Figure 6-8. Model 1978 Battery Pack, Schematic Diagram

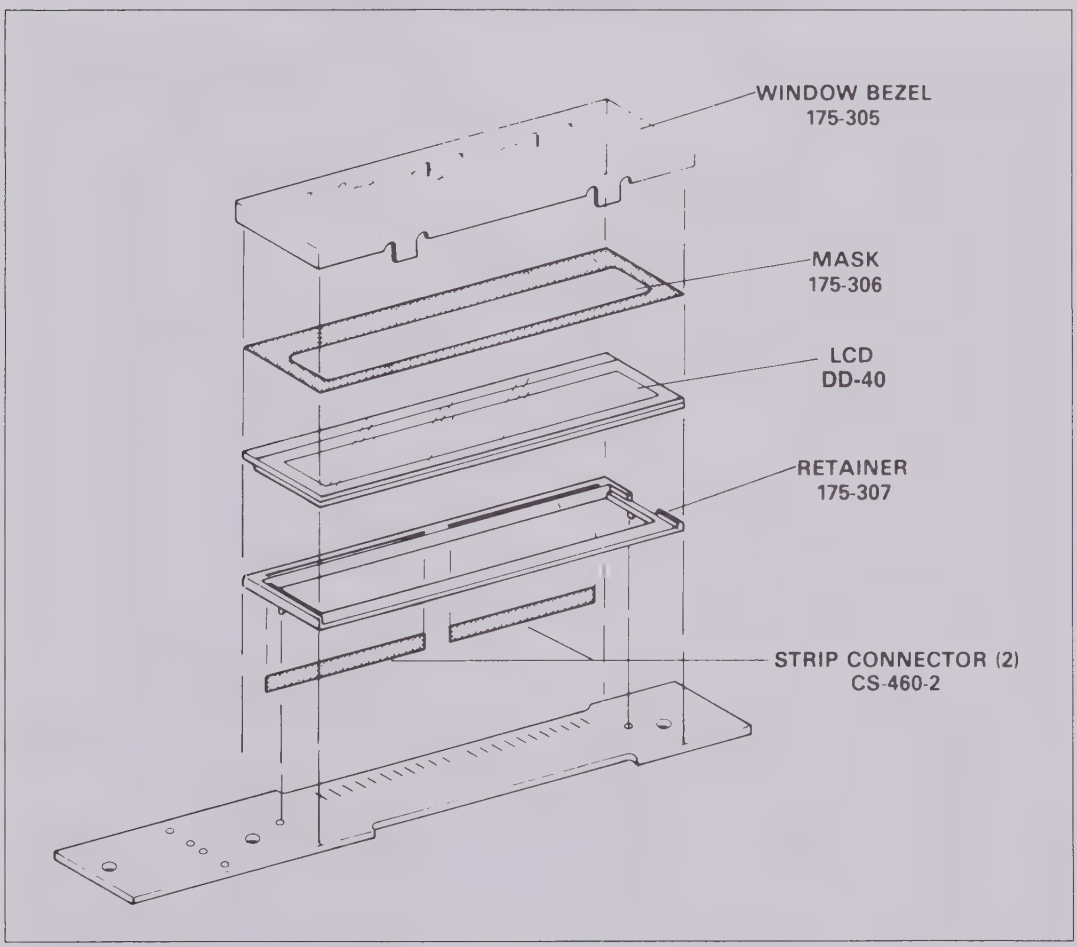


Figure 6-1. Display Assembly Exploded View

Table 6-1. Mother Board, Parts List

Circuit Desig.	Description	Schematic Location	Keithley Part No.
C101	Capacitor, 1.0μF, 50V, Polyester	1/B3	C-237-1
C102	Capacitor, 10μF, 25V, Aluminum Electrolytic	1/H5	C-314-10
C103	Capacitor, .1μF, 50V, Ceramic	1/F4	C-365-.1
C104	Capacitor, 10μF, 25V, Aluminum Electrolytic	1/H4	C-314-10
C105	Capacitor, 10μF, 25V, Aluminum Electrolytic	1/C5	C-314-10
C106	Capacitor, .0022μF, 100V, Silver Mica	1/C5	C-22-.0022
C107	Capacitor, 0.1μF, 50V, Ceramic	1/C2	C-365-.1
C108	Capacitor, 330μF, 6.3V, Aluminum Electrolytic	1/C2	C-378-330
C109	Capacitor, .0022μF, 100V, Silver Mica	1/G4	C-22-.0022
C111	Capacitor, 1500μF, 25V, Aluminum Electrolytic	1/G5	C-314-1500
C112	Capacitor, 250μF, 25V, Aluminum Electrolytic	1/G5	C-314-220
C113	Capacitor, 10μF, 25V, Aluminum Electrolytic	1/H5	C-314-10
C114	Capacitor, .01μF, 100V, Silver Mica	1/H5	C-22-.01
C115	Capacitor, 0.1μF, 50V, Ceramic	2/F2	C-365-.1
C116	Capacitor, 0.1μF, 50V, Ceramic	2/F3	C-365-.1
C117	Capacitor, 22pF, 1000V, Ceramic	2/F6	C-64-22p
C118	Capacitor, 22pF, 1000V, Ceramic	2/F6	C-64-22p
C119	Capacitor, 0.1μF, 50V, Ceramic	2/D4	C-365-.1
C120	Capacitor, 0.1μF, 50V, Ceramic	2/D6	C-365-.1
C121	Capacitor, 0.1μF, 50V, Ceramic	2/B5	C-365-.1
C122	Capacitor, 1000pF, 1000V, Ceramic	2/E2	C-64-1000p
C123	Capacitor, 15pF, 1000V, Ceramic	2/D1	C-64-15p
C124	Capacitor, 0.1μF, 50V, Ceramic	2/B2	C-365-.1
C125	Capacitor, 0.1μF, 50V, Ceramic	2/A5	C-365-.1
C126	Capacitor, 82pF, 1000V, Ceramic Disc	2/D1	C-64-82p
C127	Capacitor, .0047μF, 100VDC, Metal Polypropylene	2/E1	C-306-.0047
C128	Capacitor, 0.1μF, 50V, Ceramic	2/E3	C-365-.1
C129	Capacitor, .001μF, 100VDC, Metal Polypropylene	1/A1	C-306-.001
C130	Capacitor, 710pF, 100V, Silver Mica	1/G3	C-348-710p
C131	Capacitor, 710pF, 50V, Ceramic Disc	1/G3	C-348-710p
C132	Capacitor, 0.1μF, 50V, Ceramic	1/B1	C-365-.1
C133	Capacitor, 0.1μF, 50V, Ceramic	1/C2	C-365-.1
CR101	Rectifier, Bridge	1/G5	RF-52
CR102	Rectifier, Bridge, 1.5A	1/E2	RF-36
CR103	Rectifier, Bridge	2/E6	RF-14
CR104	Diode, Silicon, 1N914	1/E3	RF-28
CR105	Rectifier, Bridge	2/E6	RF-14
F101	Fuse, 1/8A, 250V, 3AG, Slo Blo	1/E5	FU-20
J1006	3 Pin Male Molex Connector (Line)	1/E6	175-316
J1007	14 Pin Socket	2/H3	SO-70
J1008	6 Pin Male Molex Connector (IEEE)	1/F6	175-321
J1009	Connector, Male (2 rows of 5 contacts)	1/G6	CS-389-4

Table 6-1. Mother Board, Parts List (Cont.)

Circuit Desig.	Description	Schematic Location	Keithley Part No.
J1010	External Trigger Jack	2/E5	29316-A
J1011	External Trigger Jack	2/E5	29316-A
L101	Power Filter Choke	1/C2	CH-20-2
Q101	Transistor, NPN, 2N3904 (Figure 6-2 D)	1/H5	TG-47
Q102*	Transistor, JFET, N-Channel, PN5434 (Figure 6-2 E)	1/H4	TG-198
Q103	Transistor, PNP, Silicon, 2N3906 (Figure 6-2 D)	1/C5	TG-84
Q104*	Transistor, MOSFET, N-Channel (Figure 6-2 C)	1/B3	TG-195
Q105*	Transistor, MOSFET, N-Channel (Figure 6-2 C)	1/B2	TG-195
Q106*	Transistor, JFET, P-Channel (Figure 6-2 B)	1/F4	TG-166
Q107*	Transistor, JFET, P-Channel (Figure 6-2 B)	1/F4	TG-166
Q108*	Transistor, JFET, P-Channel (Figure 6-2 B)	1/E4	TG-166
Q109*	Transistor, JFET, P-Channel (Figure 6-2 B)	1/E4	TG-166
Q110*	Transistor, MOSFET, N-Channel (Figure 6-2 A)	1/C3	TG-196
Q111*	Transistor, MOSFET, N-Channel (Figure 6-2 A)	1/C2	TG-196
Q112	Transistor, NPN, Planar, 2N3565 (Figure 6-2 F)	1/H5	TG-137
Q113*	Transistor, FET, N-Channel, 2N4392 (Figure 6-2 G)	1/A2	TG-128
Q114*	Transistor, JFET, P-Channel (Figure 6-2 B)	1/A1	TG-166
Q115*	Transistor, MOSFET, N-Channel (Figure 6-2 C)	1/E4	TG-195
Q116*	Transistor, MOSFET, N-Channel (Figure 6-2 C)	1/D2	TG-195
Q117*	Transistor, MOSFET, N-Channel Selected (Fig. 6-2 A)	1/E4	580-601
Q118*	Transistor, MOSFET, N-Channel Selected (Fig. 6-2 A)	1/E4	580-601
Q119*	Transistor, MOSFET, N-Channel Selected (Fig. 6-2 A)	1/D1	580-601
Q120*	Transistor, MOSFET, N-Channel (Figure 6-2 C)	1/D3	TG-195
Q121*	Transistor, MOSFET, N-Channel (Figure 6-2 C)	1/D2	TG-195
Q122*	Transistor, FET, N-Channel 2N4392 (Figure 6-2 G)	2/B1	TG-128
Q123*	Transistor, MOSFET, N-Channel (Figure 6-2 E)	2/C1	TG-174
Q124*	Transistor, MOSFET, N-Channel Selected (Fig. 6-2 A)	1/E2	580-601
Q125*	Transistor, MOSFET, N-Channel Selected (Fig. 6-2 A)	1/F1	580-601
Q126*	Transistor, MOSFET, N-Channel Selected (Fig. 6-2 A)	1/F2	580-601
Q127*	Transistor, MOSFET, N-Channel Selected (Fig. 6-2 A)	1/F1	580-601
Q128*	Transistor, MOSFET, N-Channel Selected (Fig. 6-2 A)	1/F2	580-601
Q129*	Transistor, JFET, P-Channel (Figure 6-2 B)	1/G2	TG-166
Q130*	Transistor, JFET, P-Channel (Figure 6-2 B)	1/F4	TG-166
Q131	Transistor, NPN, 2N5089 (Figure 6-2 D)	1/G2	TG-62
Q132	Transistor, NPN, 2N5089 (Figure 6-2 D)	1/F3	TG-62
Q133*	Transistor, FET, MP842 (Figure 6-2 H)	2/D1	TG-175
Q134	Transistor, MOSFET, N-Channel Selected (Fig. 6-2 A)	1/E4	580-601
R101	Resistor Network	Sev	TF-198
R102	Resistor, 1kΩ, 5%, ¼W, Composition	1/H5	R-76-1k
R103	Resistor, 10Ω, 5%, ¼W, Composition	1/B2	R-76-10

*CMOS, MOS static-sensitive devices. Refer to paragraph 5.7 for handling information.

Table 6-1. Mother Board, Parts List (Cont.)

Circuit Desig.	Description	Schematic Location	Keithley Part No.
R104	Resistor, 6.19kΩ, 0.1%, $^1/_{10}$W, Metal Film	1/G4	R-263-6.19k
R105	Resistor, 22.5kΩ, 0.1%, $^1/_{10}$W, Metal Film	1/F4	R-263-22.5k
R106	Resistor, 100Ω, 5%, ¼W, Composition	1/B2	R-76-100
R107	Resistor, 14Ω, 1%, 1W, Wire Wound	1/E4	R-340-14
R108	Resistor, 0.15Ω, 1%, 2W, Wire Wound	1/E4	R-342-0.15
R109	Resistor, 1.9Ω, 1%, 5W, Wire Wound	1/E4	R-341-1.9
R110	Resistor, 47kΩ, 5%, ¼W, Composition	1/B1	R-76-47k
R111	Resistor, 100Ω, 5%, ¼W, Composition	1/B3	R-76-100
R112	Resistor, 330Ω, 10%, ½W, Composition	1/G5	R-1-330
R113	Resistor Network	Sev	TF-103-3
R114	Resistor, 200kΩ, 5%, ¼W, Composition	1/F5	R-76-200k
R115	Resistor, 200kΩ, 5%, ¼W, Composition	1/E5	R-76-200k
R116	Resistor, 22.2kΩ, 0.1%, $^1/_{10}$W, Metal Film	1/A1	R-263-22.2k
R117	Resistor, 10Ω, 10%, 2W, Composition	1/G5	R-3-22
R118	Resistor, Thick Film, Network	Sev	TF-194
R119	Resistor, 47kΩ, 5%, ¼W, Composition	2/F3	R-76-47k
R120	Resistor, 199.3kΩ, 0.1%, $^1/_{10}$W, Metal Film	1/A1	R-263-199.3k
R121	Resistor, 90Ω, 0.1%, ½W, Metal Film	1/D2	R-169-90
R122	Resistor, 10MΩ, 10%, ¼W, Composition	2/F6	R-76-10M
R123	Resistor, 10Ω, 0.1%, 5W	1/D1	R-185-10
R124	Resistor, 100kΩ, 0.1%, $^1/_{10}$W, Metal Film	1/D2	R-263-100k
R125	Resistor, 1.002kΩ, 0.1%, $^1/_{10}$W, Metal Film	1/D2	R-263-1.002k
R126	Resistor, 10kΩ, 0.1%, $^1/_{10}$W, Metal Film	1/G3	R-263-10k
R127	Resistor, Thick Film, Network	Sev	TF-175
R128	Resistor, 10kΩ, 0.1%, $^1/_{10}$W, Metal Film	1/G3	R-263-10k
R129	Resistor, 200Ω, 0.1%, $^1/_{10}$W, Wire Wound	1/G3	R-291-200
R130	Resistor, 1kΩ, 1%, 1W, Wire Wound	1/G3	R-343-1k
R131	Resistor, 200kΩ, 5%, ¼W, Composition	1/E4	R-76-200k
R132	Resistor, 200kΩ, 1%, $^1/_8$W, Metal Film	1/B1	R-88-200k
R133	Resistor, 17.4kΩ, 1%, $^1/_8$W, Metal Film	2/B1	R-88-17.4k
R134	Resistor, 28kΩ, 1%, $^1/_8$W, Metal Film	2/B1	R-88-28.0k
R135	Resistor, 7.78kΩ, 0.1%, $^1/_8$W, Metal Film	2/C1	R-176-7.78k
R136	Resistor, 1MΩ, 0.1%, $^1/_8$W, Metal Film	2/E1	R-176-1M
R137	Resistor, 22kΩ, 5%, ¼W, Composition	±/E2	R-76-22k
R138	Resistor, 10kΩ, 1%, $^1/_8$W, Metal Film	2/B2	R-88-10k
R139	Resistor, 10kΩ, 1%, $^1/_8$W, Metal Film	2/C2	R-88-10k
R140	Resistor, 1kΩ, 1%, 1W, Wire Wound	1/G2	R-343-1k
R141	Resistor, 1kΩ, 1%, 1W, Wire Wound	1/F4	R-343-1k
R142	Resistor, Thick Film, Network	Sev	TF-196
R143	Resistor, 22kΩ, 5%, ¼W, Composition	2/A3	R-76-22k
R144	Resistor, 10kΩ, 5%, ¼W, Composition	1/E2	R-76-10k
R145	Resistor, 100kΩ, 5%, ¼W, Composition	1/F2	R-76-100k
R146	Resistor, 100kΩ, 5%, ¼W, Composition	1/E2	R-76-100k
R147	Resistor, 100kΩ, 5%, ¼W, Composition	1/F1	R-76-100k
R148	Resistor, 100kΩ, 5%, ¼W, Composition	1/E1	R-76-100k

Table 6-1. Mother Board, Parts List (Cont.)

Circuit Desig.	Description	Schematic Location	Keithley Part No.
R149	Resistor, 1kΩ, 1%, 1W, Wire Wound	1/F2	R-343-1k
R150	Resistor, 1kΩ, 1%, 1W, Wire Wound	1/G2	R-343-1k
R151	Resistor, 22kΩ, 5%, ¼W, Composition	2/F6	R-76-22k
R152	Resistor, 5.1kΩ, 5%, ¼W, Composition	2/D3	R-76-5.1k
R153	Resistor, 15kΩ, 5%, ¼W, Composition	2/D3	R-76-15k
R154	Resistor, 150kΩ, 5%, ¼W, Composition	2/E3	R-76-150k
R155	Resistor, 5.1kΩ, 5%, ¼W, Composition	2/D3	R-76-5.1k
R156	Resistor, 22kΩ, 5%, ¼W, Composition	2/E6	R-76-22k
R157	Resistor, 1kΩ, 5%, ¼W, Composition	2/E5	R-76-1k
R158	Resistor, 1kΩ, 5%, ¼W, Composition	2/E5	R-76-1k
R159	Resistor, 47kΩ, 5%, ¼W, Composition	1/F3	R-76-47k
R160	Resistor, 15kΩ, 5%, ¼W, Composition	1/C4	R-76-15k
R161	Resistor, 200kΩ, 5%, ¼W, Composition	1/F3	R-76-200k
R162	Resistor, 1kΩ, 1%, 1W, Wire Wound	1/E5	R-343-1k
R163	Resistor, 200kΩ, 5%, ¼W, Composition	1/E4	R-76-200k
R164	Resistor, 22kΩ, 5%, ¼W, Composition	2/H6	R-76-22k
RT-101	Thermistor	1/F1	RT-14
S101	Switch, Pushbutton	1/G5,6	SW-463
S102	Switch, Slide	1/F5	SW-318
S103	Switch, Calibration	2/H6	SW-465
T101	Transformer, Power, (105V-125V, 210V-250V)	1/F5	TR-201
T101	Transformer, Power, (Japanese Version)	1/F5	TR-202
T102	Transformer	1/B2	TR-238
T103	Transformer	1/F5	TR-214
T104	Transformer	1/E5	TR-214
T105	Transformer	1/G1	TR-241
U101	Op Amp, 741	1/H3	IC-42
U102*	Progammable Op Amp, TLC271	1/B5	IC-347
U103*	8 Stage Shift/Store Register, MC14094BCP	1/D5	IC-251
U104*	8 Stage Shift/Store Register, MC14094BCP	1/D3	IC-251
U105*	Inverting High Speed Op Amp, MP5501CP	1/H5	IC-414
U106*	Low Noise Op Amp, LT1012	1/H3	IC-394
U107*	CMOS 8-Channel Multiplexer	1/B1	IC-459
U108*	Low Noise Op Amp, LT1012	1/A1	IC-394
U109	Quad Comparator, LM339	Sev	IC-219
U110*	Triple 3-Input NAND Gate, MM74HC10	Sev	IC-341
U111*	Peripheral Interface Adapter, 65C21	2/B3	LSI-61
U112*	CMOS 8-Bit Microprocessor, 146805E2	2/F4	LSI-60
U113*	Quad 2-Input NAND Gate, 74HC00	Sev	IC-351

*CMOS, MOS Static-sensitive devices. Refer to paragraph 5.7 for handling information.

Table 6-1. Mother Board, Parts List (Cont.)

Circuit Desig.	Description	Schematic Location	Keithley Part No.
U114*	Triple 3-Input OR Gate, CD4075BE	Sev	IC-143
U115*	Triple 2-Channel Analog Multplier, CD4053BC	Sev	IC-283
U116*	Tri-State Octal D-Latch, 74HC573	2/D6	IC-458
U117*	ROM	2/C5	580-800
U118*	1024 × 4 Bit Static CMOS RAM	2/A5	LSI-62
U119*	Op Amp, Low Noise, Selected	1/G3	580-600
U120*	Op Amp, Low Noise, Selected	1/F3	580-600
U121*	Dual D Flip-Flop, 74HC74	2/E2	IC-337
U122*	Op Amp, MP5502DP	2/D1	IC-413
U123*	12 Stage Binary Counter, 4040B	2/F2	IC-348
U124	Dual Voltage Comparator, LM393	2/E1	IC-343
U125*	16 × 16 Bit Serial Non Volatile Static RAM X2443P	2/D3	IC-353
U126	Dual Voltage Comparator, LM393	2/E3	IC-343
U127*	Dual Op Amp, TL272LCP	Sev	IC-415
VR101	Diode, Zener, 6.26V, 1N4577	1/G4	DZ-58
VR102	Diode, Zener, 6.26V, 1N4577	1/B5	DZ-58
VR103	Diode, Zener, 8.2V, 1N756A	1/C5	DZ-61
VR104	Diode, Zener, 15V, 1N5352	1/G5	DZ-76
VR105	Diode, Zener, 15V, 1N4744	1/G5	DZ-75
Y101	Crystal, 3.84MHz	2/F6	CR-26
	Fuse Holder		FH-12

*CMOS, MOS Static-Sensitive device. Refer to paragraph 5.7 for handling information.

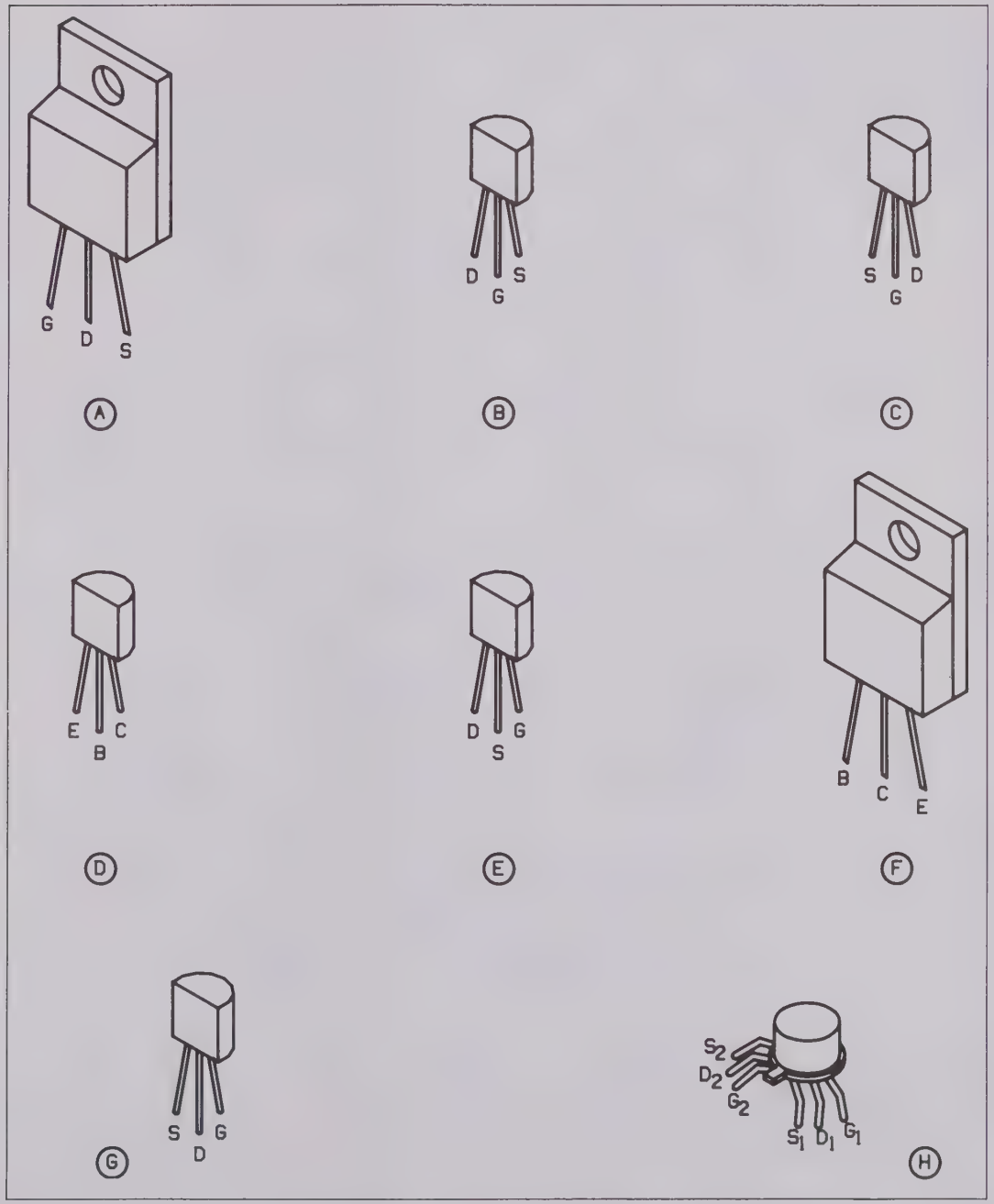


Figure 6-2. Transistor FET Types

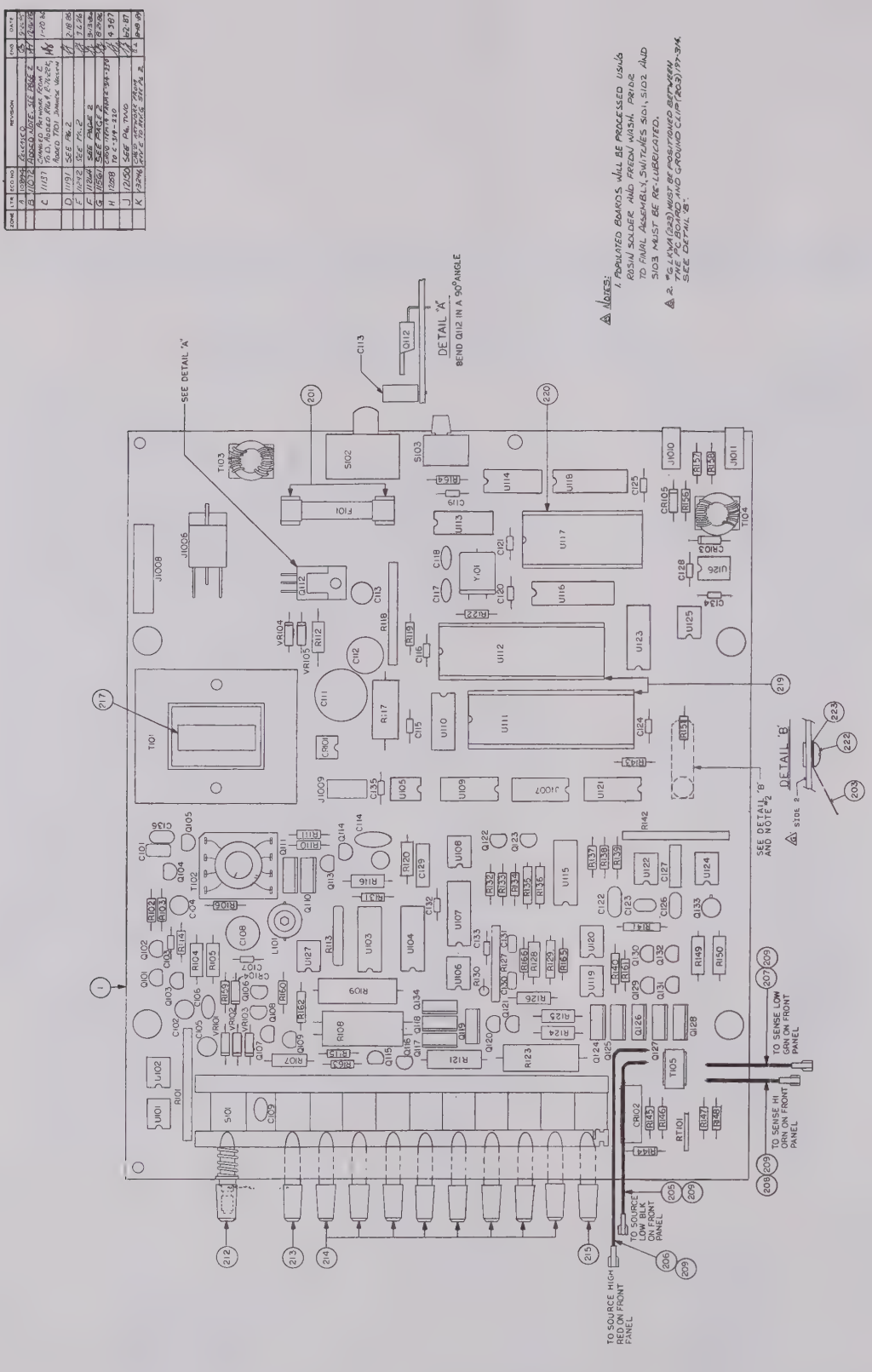

SEE DETAIL 'A'
DETAIL 'A'
BEND Q112 IN A 90° ANGLE
DETAIL 'B'
SEE DETAIL 'B' AND NOTE #2
SIDE 2
TO SOURCE HIGH RED ON FRONT PANEL
TO SOURCE LOW BLK ON FRONT PANEL
TO SENSE LOW GRN ON FRONT PANEL
TO SENSE HI GRN ON FRONT PANEL

Figure 6-3. Mother Board, Component Location Drawing, Dwg. No. 580-100

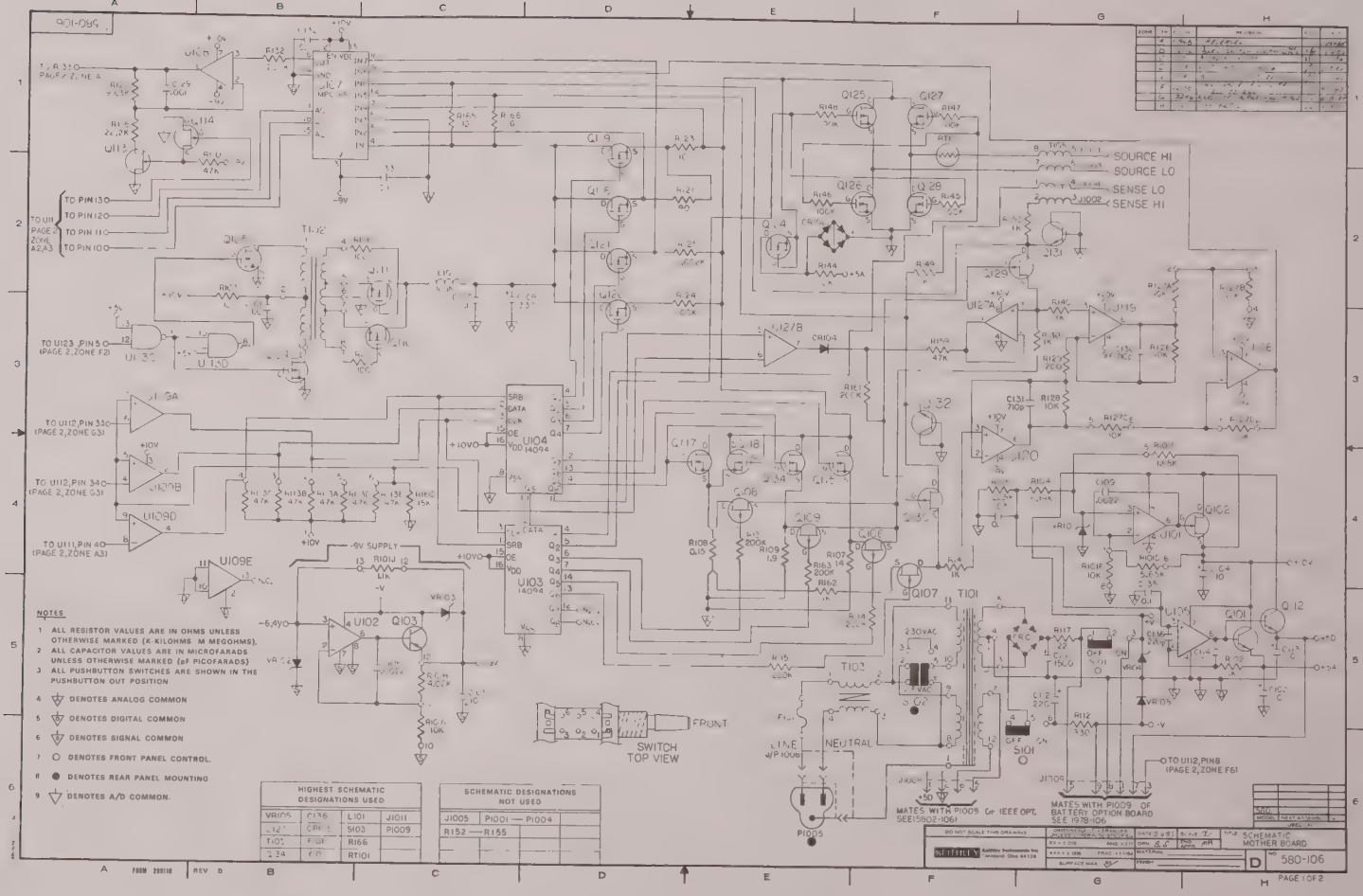

SOURCE HI
SOURCE LO
SENSE LO
SENSE HI
SWITCH TOP VIEW
FRONT
NOTES
1 ALL RESISTOR VALUES ARE IN OHMS UNLESS OTHERWISE MARKED (K-KILOHMS M MEGOHMS).
2 ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS OTHERWISE MARKED (pF PICOFARADS)
3 ALL PUSHBUTTON SWITCHES ARE SHOWN IN THE PUSHBUTTON OUT POSITION
4 DENOTES ANALOG COMMON
5 DENOTES DIGITAL COMMON
6 DENOTES SIGNAL COMMON
7 DENOTES FRONT PANEL CONTROL.
8 DENOTES REAR PANEL MOUNTING
9 DENOTES A/D COMMON.
HIGHEST SCHEMATIC DESIGNATIONS USED
SCHEMATIC DESIGNATIONS NOT USED
SCHEMATIC MOTHER BOARD
580-106
PAGE 1 OF 2

Figure 6-4. Mother Board, Schematic Diagram, Dwg. No. 580-106 (sheet 1 of 2)

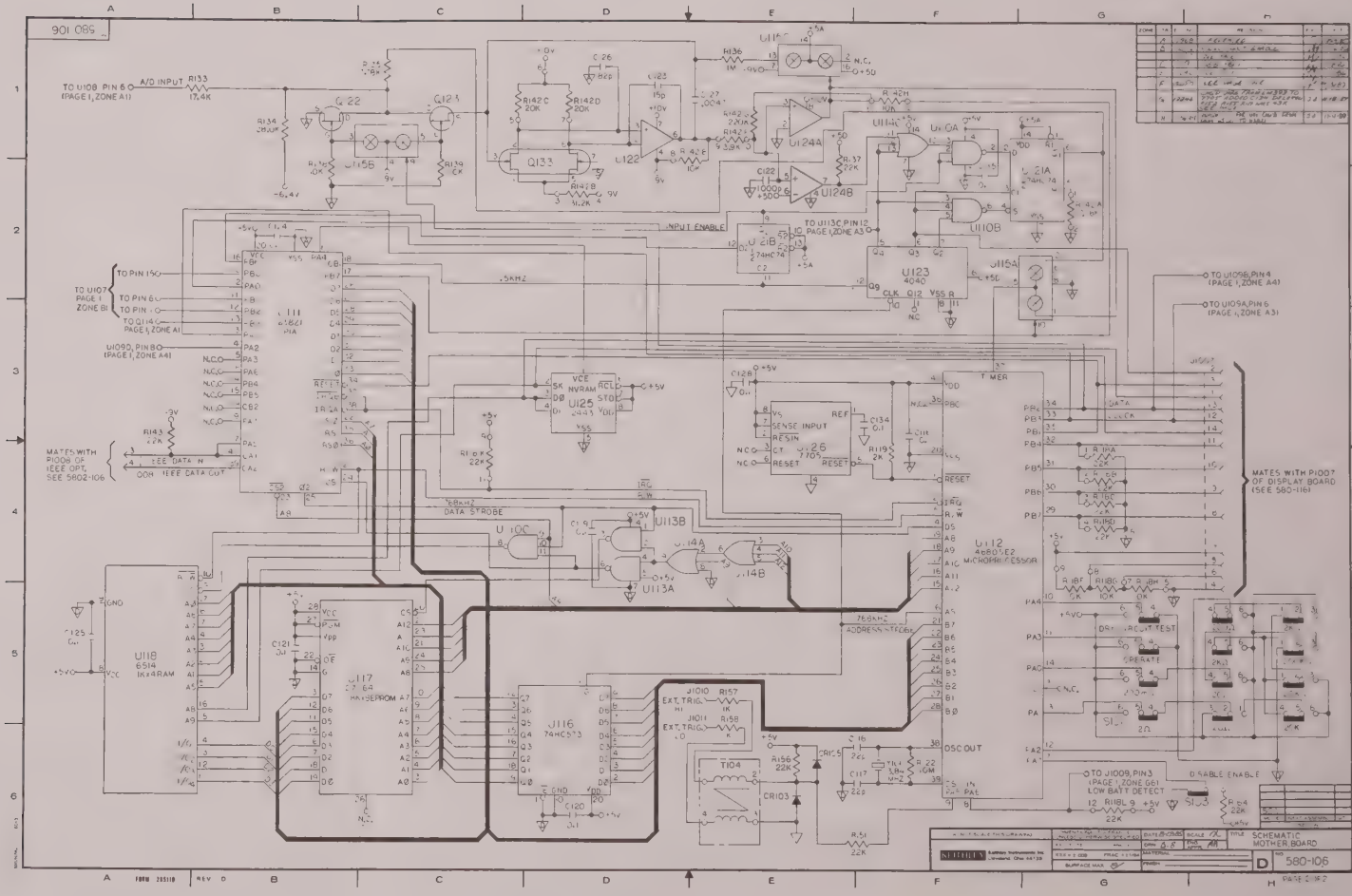


Figure 6-4. Mother Board, Schematic Diagram, Dwg. No. 580-106 (sheet 2 of 2)

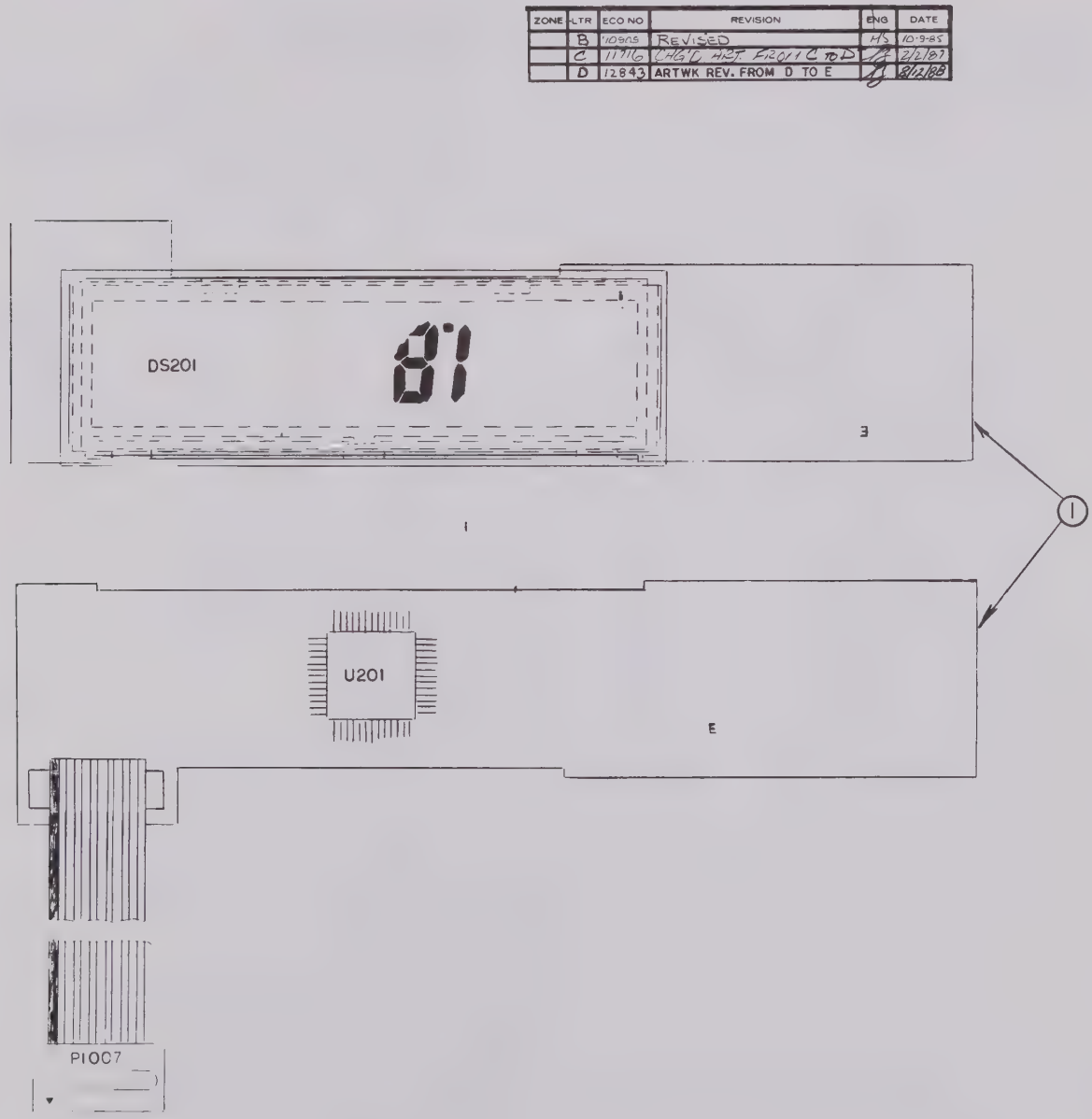


Figure 6-5. Display Board, Component Location Drawing, Dwg. No. 580-110

Table 6-2. Display Board, Parts List

Circuit Desig.	Description	Schematic Location	Keithley Part No.
DS201	LCD Display	C2	DD-40
P1007	Cable Assembly-14 cond.	B5	CA-30-3
U201*	Integrated Circuit	D3	LSI-59
	Zebra Retainer		175-307
	Zebra Strip		CS-460-2
	Window Bezel		175-305
	LCD Mask		175-306

*CMOS static-sensitive device. Refer to paragraph 5.7 for handling information.

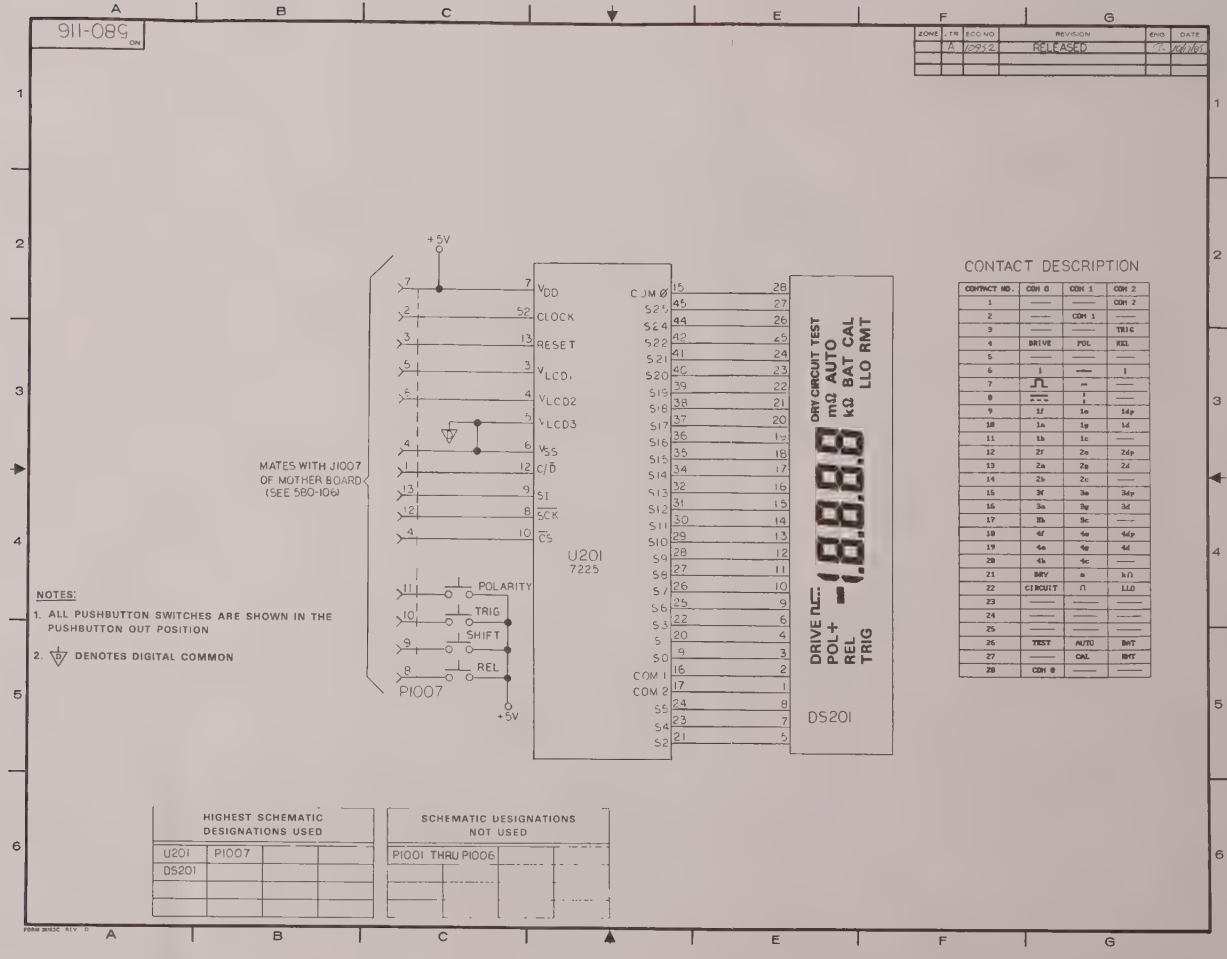


Figure 6-6. Display Board, Schematic Diagram, Dwg. No. 580-116

Table 6-3. Model 1978 Battery Pack, Parts List

Circuit Desig.	Description	Schematic Location	Keithley Part No.
BT101	Battery Assembly, 12.0V Sealed Rechargeable NiCad	—	BA-40
C101	Capacitor, 250μF, 25V, Aluminum Electrolytic	D2	C-314-220
C102	Capacitor, 10μF, 25V, Aluminum Electrolytic	D3	C-314-10
CR101	Rectifier, Schottky Barrier, 1N5820	D2	RF-53
J1010	Pin	C3	CS-463
J1011	Pin	C3	CS-463
P1009	Cable Assembly, 10 Conductor	D2	CA-27-1
Q101	Transistor, NPN, High Voltage (TIP-49)	C2	TG-137
R101	Resistor, 4.7Ω, 10%, 1W, Wirewound	E2	R-334-4.7
R102	Resistor, 4.7Ω, 5%, ¼W, Composition	E1	R-76-4.7
R103	Resistor, 44.2k, 1%, $^1/_8$W, Metal Film	E3	R-88-44.2k
R104	Resistor, 37.4k, 1%, $^1/_8$W, Metal Film	E3	R-88-37.4k
R105	Resistor, 1.2M, 5%, ¼W, Composition	D3	R-76-1.2M
RT101	PTC Thermistor	B2	RT-10
U101*	Voltage Converter, S17661CJ	D3	IC-340
U102	Voltage Comparator, LM393	D3	IC-343
	Heat Sink used on U101	D3	HS-28
	Standoff (Battery Board to Shield)	D3	ST-156-2

*CMOS static-sensitive device. Refer to paragraph 5.7 for handling information.

LTR	ECO NO	REVISION	ENG	DATE
A	9882	RELEASED	[illegible]	5-31-84
B	10402	R101 WAS R-1-4.7	[illegible]	12-27-84
C	10967	CHG'D REV FROM D TO F	[illegible]	[illegible]
D	12056	CHG'D ITEM 3 FROM C-314-250 TO C-314-220	[illegible]	4-3-87

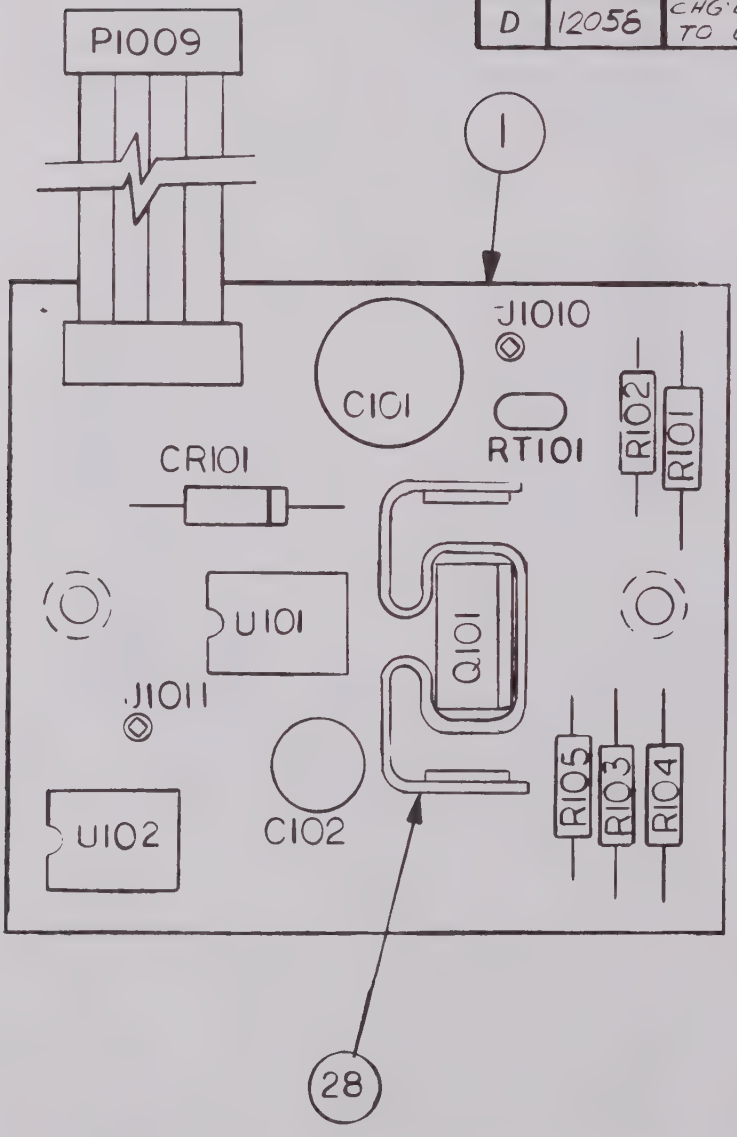


Figure 6-7. Model 1978 Battery Pack, Component Location Drawing, Dwg. No. 1978-100

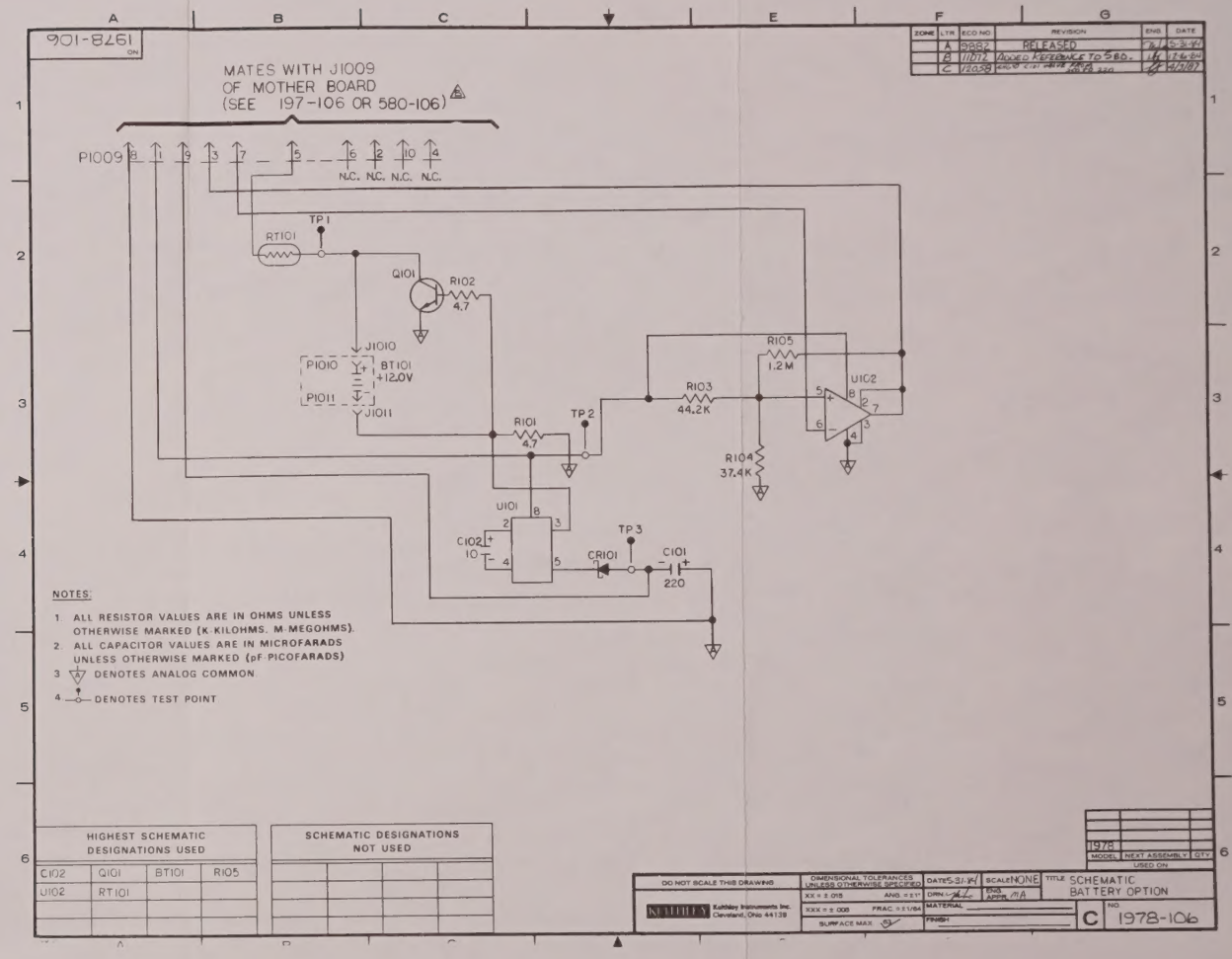


Figure 6-8. Model 1978, Battery Pack, Schematic Diagram, Dwg. No. 1978-106

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